FRANK H. NETTER, MD

ATLAS OF HUMAN ANATOMY

6th EDITION

25 ANNIVERSARY EDITION

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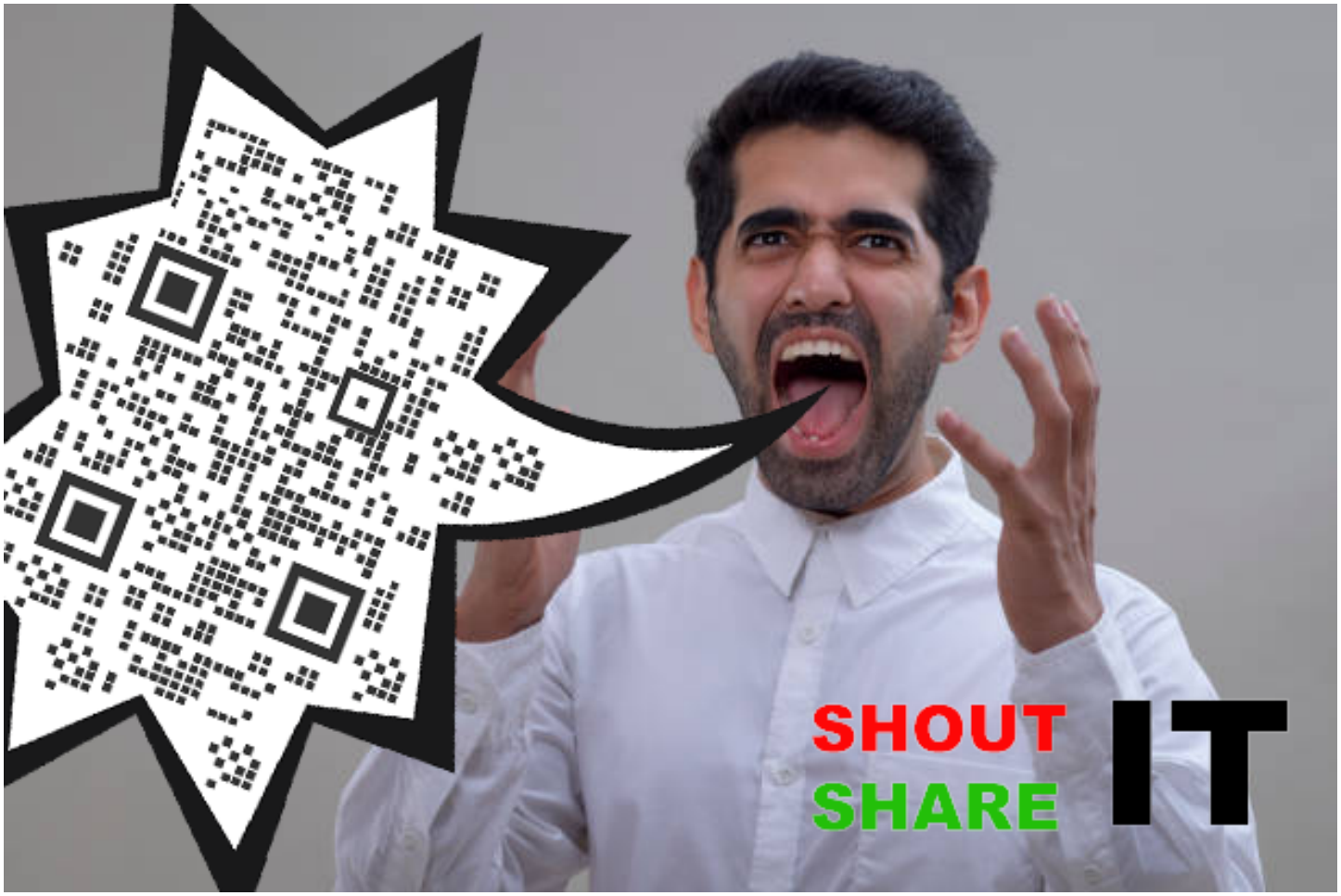
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Bonus Plates

BONUS PLATES

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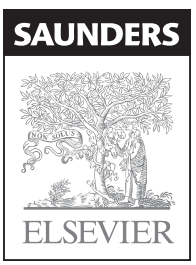

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Netter's Atlas of Human Anatomy – Celebrating 25 Years

"Anatomy, of course, does not change, but our understanding of anatomy and its clinical significance does."

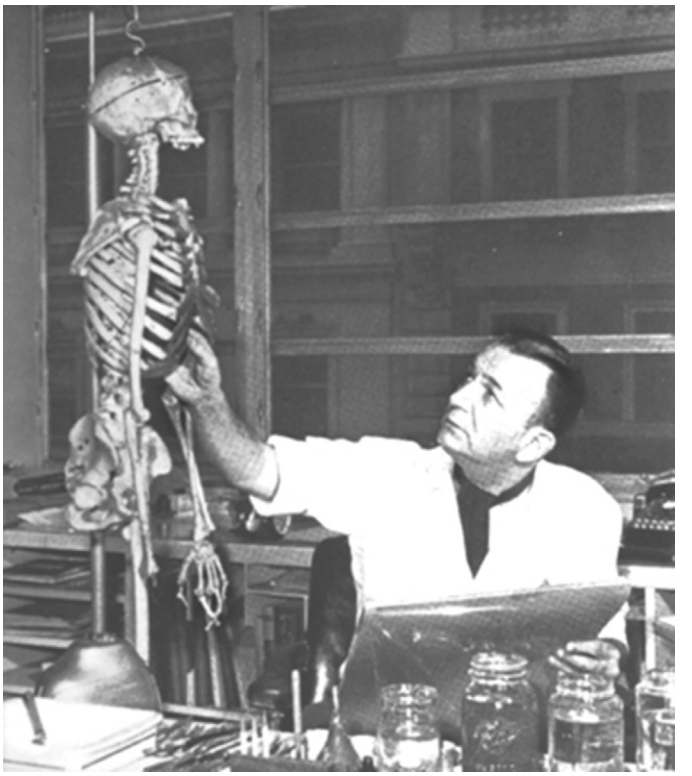
– **Frank H. Netter, MD**

Whether you're using this 6th edition of ***Atlas of Human Anatomy*** in print, as an e-Book, online, or in the Netter's Anatomy Atlas for iPad app—Dr. Netter's paintings of the intricacies of the human form remain as relevant today as at first launch. The publication of the 6th edition marks the silver anniversary of the first release of Frank H. Netter's *Atlas of Human Anatomy*—when its vibrant colors and unique clinical perspective made it a must-have companion in anatomy classes, dissection labs, and clinical professional offices worldwide—solidifying his legacy to so many as one of the world's most influential medical educators.

Anatomy remains a cornerstone of healthcare education. It is often one of the first topics taught in medical or healthcare curricula. Anatomy is also central to so much in clinical practice, from physical examination and radiologic imaging to surgery and physical rehabilitation. However, changes in anatomy education and its clinical application over these past 25 years have been significant. Medical and healthcare curricula increasingly integrate anatomy throughout and dedicated gross-anatomy hours have decreased. Some programs have discontinued full-body dissection. Advances in imaging technology have provided increasingly clearer views of living anatomy, and 3D models of anatomy continue to evolve. Likewise, the *Atlas* has evolved. Thanks to the tremendous guidance of leading clinical anatomists and expert anatomy educators, as well as the contributions of talented medical illustrators, the 6th edition features newly created illustrations and modern radiologic images that provide students with views of current clinical significance and perspectives that elucidate complex anatomic relationships. This edition also includes the illustrations from older editions of the *Atlas*, like Dr. Netter's depictions of common anatomic variations (in electronic editions and print+electronic packages) as bonus plates to help provide more comprehensive coverage that dissection lab hours may not allow. For the first time, the *Atlas* incorporates muscle tables as quick look-up appendices at the end of each section for the convenience of the clinician, student, or educator with little time. StudentConsult.com and NetterReference.com electronic resources include some 3D models extracted from Netter's 3D Interactive Anatomy, dissection video selections from Netter's Online Dissection Modules by UNC at Chapel Hill, and other supporting resources. In addition, all text throughout the Atlas has been meticulously updated to be in line with the most recent version of *Terminologia Anatomica* by the Federal International Program for Anatomical Terminology (FIPAT) of the International Federation of Associations of Anatomists (IFAA).

The unique visual perspective of Frank H. Netter is unsurpassed. Dr. Netter brought the hand of a master medical illustrator, the brain of a physician, and the soul of an artist to his depictions of the human body. This 25th anniversary edition celebrates the lasting impact of his work that continues to teach and inspire.

We want to hear from you—about the history and future of anatomy education and medicine and the Netter legacy and invite you to share your thoughts, inspirations, memories, tributes, and feedback with us through email: NetterAppFeedback@elsevier.com and on Facebook: www.facebook.com/NetterImages



Frank H. Netter, MD
Photograph by James L. Clayton

To my dear wife, Vera

Frank H. Netter, MD

Frank H. Netter was born in New York City in 1906. He studied art at the Art Students League and the National Academy of Design before entering medical school at New York University, where he received his Doctor of Medicine degree in 1931. During his student years, Dr. Netter's notebook sketches attracted the attention of the medical faculty and other physicians, allowing him to augment his income by illustrating articles and textbooks. He continued illustrating as a sideline after establishing a surgical practice in 1933, but he ultimately opted to give up his practice in favor of a full-time commitment to art. After service in the United States Army during World War II, Dr. Netter began his long collaboration with the CIBA Pharmaceutical Company (now Novartis Pharmaceuticals). This 45-year partnership resulted in the production of the extraordinary collection of medical art so familiar to physicians and other medical professionals worldwide.

Icon Learning Systems acquired the Netter Collection in July 2000 and continued to update Dr. Netter's original paintings and to add newly commissioned paintings by artists trained in the style of Dr. Netter. In 2005, Elsevier Inc. purchased the Netter Collection and all publications from Icon Learning Systems. There are now over 50 publications featuring the art of Dr. Netter available through Elsevier Inc.

Dr. Netter's works are among the finest examples of the use of illustration in the teaching of medical concepts. The 13-book *Netter Collection of Medical Illustrations,* which includes the greater part of the more than 20,000 paintings created by Dr. Netter, became and remains one of the most famous medical works ever published. *The Netter Atlas of Human Anatomy,* first published in 1989, presents the anatomic paintings from the Netter Collection. Now translated into 16 languages, it is the anatomy atlas of choice among medical and health professions students the world over.

The Netter illustrations are appreciated not only for their aesthetic qualities, but, more importantly, for their intellectual content. As Dr. Netter wrote in 1949 "clarification of a subject is the aim and goal of illustration. No matter how beautifully painted, how delicately and subtly rendered a subject may be, it is of little value as a *medical illustration* if it does not serve to make clear some medical point." Dr. Netter's planning, conception, point of view, and approach are what inform his paintings and what make them so intellectually valuable.

Frank H. Netter, MD, physician and artist, died in 1991.

Preface to the First Edition

I have often said that my career as a medical artist for almost 50 years has been a sort of "command performance" in the sense that it has grown in response to the desires and requests of the medical profession. Over these many years, I have produced almost 4,000 illustrations, mostly for *The CIBA* (now *Netter*) *Collection of Medical Illustrations* but also for *Clinical Symposia.* These pictures have been concerned with the varied subdivisions of medical knowledge such as gross anatomy, histology, embryology, physiology, pathology, diagnostic modalities, surgical and therapeutic techniques, and clinical manifestations of a multitude of diseases. As the years went by, however, there were more and more requests from physicians and students for me to produce an atlas purely of gross anatomy. Thus, this atlas has come about, not through any inspiration on my part but rather, like most of my previous works, as a fulfillment of the desires of the medical profession.

It involved going back over all the illustrations I had made over so many years, selecting those pertinent to gross anatomy, classifying them and organizing them by system and region, adapting them to page size and space, and arranging them in logical sequence. Anatomy of course does not change, but our understanding of anatomy and its clinical significance does change, as do anatomical terminology and nomenclature. This therefore required much updating of many of the older pictures and even revision of a number of them in order to make them more pertinent to today's ever-expanding scope of medical and surgical practice. In addition, I found that there were gaps in the portrayal of medical knowledge as pictorialized in the illustrations I had previously done, and this necessitated my making a number of new pictures that are included in this volume.

In creating an atlas such as this, it is important to achieve a happy medium between complexity and simplification. If the pictures are too complex, they may be difficult and confusing to read; if oversimplified, they may not be adequately definitive or may even be misleading. I have therefore striven for a middle course of realism without the clutter of confusing minutiae. I hope that the students and members of the medical and allied professions will find the illustrations readily understandable, yet instructive and useful.

At one point, the publisher and I thought it might be nice to include a foreword by a truly outstanding and renowned anatomist, but there are so many in that category that we could not make a choice. We did think of men like Vesalius, Leonardo da Vinci, William Hunter, and Henry Gray, who of course are unfortunately unavailable, but I do wonder what their comments might have been about this atlas.

Frank H. Netter, MD
(1906–1991)

Acknowledgments

Brion Benninger, MD, MS

I would like to thank my wife, Alison, and our son, Jack, for their wit, caring, and the love they provide me daily. I want to thank Elsevier, especially Marybeth Thiel, for her insight and direction, enabling John Hansen, my fellow coeditors, and Carlos Machado to work in such a rich environment. I particularly want to thank my early clinical anatomy mentors, Gerald Tressidor and Harold Ellis (Guy's Hospital); Dean P. Crone and the University Board for continuous support; all my past and future patients and students; and clinical colleagues who keep anatomy dynamic. Special thanks to Jim McDaniel and Bill Bryan and all who represent what is good in teaching. Lastly, I thank my mother for her love of education and my father for his inquisitive mind.

Jennifer Brueckner-Collins, PhD

I am very grateful to the wonderful Elsevier team, particularly Marybeth Thiel and Elyse O'Grady, for their guidance and expertise during our preparation of the sixth edition. It is always privilege to collaborate with Carlos Machado, whose artistic talent brings our anatomical visions from concept to reality. Sincere thanks to Mark Sturgill, DO, who most generously provided us with updated images for abdominal MRCP, axial and coronal CT with contrast, as well as CT angiography. Finally, I am eternally indebted to my parents, John and Rheba, and to my husband, Kurt, for their support, encouragement, love, and inspiration; they are my raison d'etre.

John T. Hansen, PhD

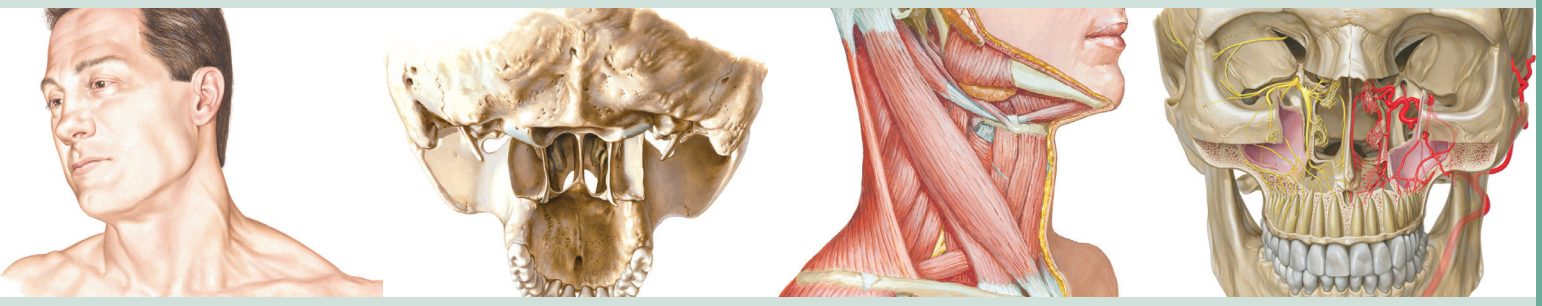
At Elsevier I would like to thank Marybeth Thiel, Senior Development Editor, Elyse O'Grady, Senior Content Strategist, John Casey, Senior Project Manager, and Madelene Hyde, Publishing Director, for their continuous support and meticulous attention to detail during the development of this sixth edition of the *Atlas of Human Anatomy.* They, along with the entire Editorial, Production, Design, and Marketing team at Elsevier have been a delight to work with and to know. I am also indebted to Carlos Machado for his superb artistic skill in producing and updating plates appearing in the *Atlas*. His renderings of human anatomy are the perfect complement to the Netter images. In addition to my fellow editors of this edition, I wish to express my thanks to my faculty colleagues at Rochester and to all my past and present students who have provided generous and constructive feedback and have enriched my life. Finally, I am indebted to my entire family for their continued support and especially to my wife, Paula. Their love and encouragement sustains me and is the source of all the happiness and joy I know.

Todd M. Hoagland, PhD

It is a privilege to teach clinical human anatomy and I am eternally grateful to all the body donors and their families for enabling healthcare professionals to train in the dissection laboratory. It is my honor to work with outstanding medical students and colleagues at the Medical College of Wisconsin. I am grateful to John Hansen and the professionals of the Elsevier team for the opportunity to be a steward of the incomparable *Netter Atlas*. Marybeth Thiel and Elyse O'Grady were especially helpful and a pleasure to work with. It was an honor to collaborate with the brilliant Carlos Machado and all the consulting editors. I thank Joe Besharse for being an outstanding mentor. I am deeply appreciative of Stan Hillman and Jack O'Malley for inspiring me with masterful teaching and rigorous expectations. I am indebted to Richard Hoyt, Jr., for helping me become a competent anatomist, and to Rob Bouchie for his support. I am most grateful to my brother, Bill, for his unwavering optimism and gregarious nature. I thank my mother, Liz, for her dedication and love and for instilling a strong work ethic. Finally, I am humbled by my two awesome children, Ella and Caleb, for helping me redefine love, wonder, and joy.

R. Shane Tubbs, MS, PA-C, PhD

First and foremost, I would like to thank Elsevier and in particular, Madelene Hyde, Marybeth Thiel, and Elyse O'Grady for all of their hard work in making this edition come to life. The evolution of the current atlas continues with the superb skills of Dr. Carlos Machado and his works of art. I would like to thank Dr. Satinder Singh for his kind assistance in providing radiographic images of the heart. I thank my beautiful wife, Susan, and son, Isaiah, for their patience and guidance during the editing of the sixth edition. Without the continued support of my mentor, friend, and colleague, Dr. W. Jerry Oakes, I could not fulfill all of my academic endeavors. I dedicate my efforts in this edition to my late brother-in-law, Nelson Jones, whose appetite for inquisitiveness inspires me today.



Section

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147 Subependymal Veins of Brain

148 Hypothalamus and Hypophysis

149 Arteries and Veins of Hypothalamus and Hypophysis

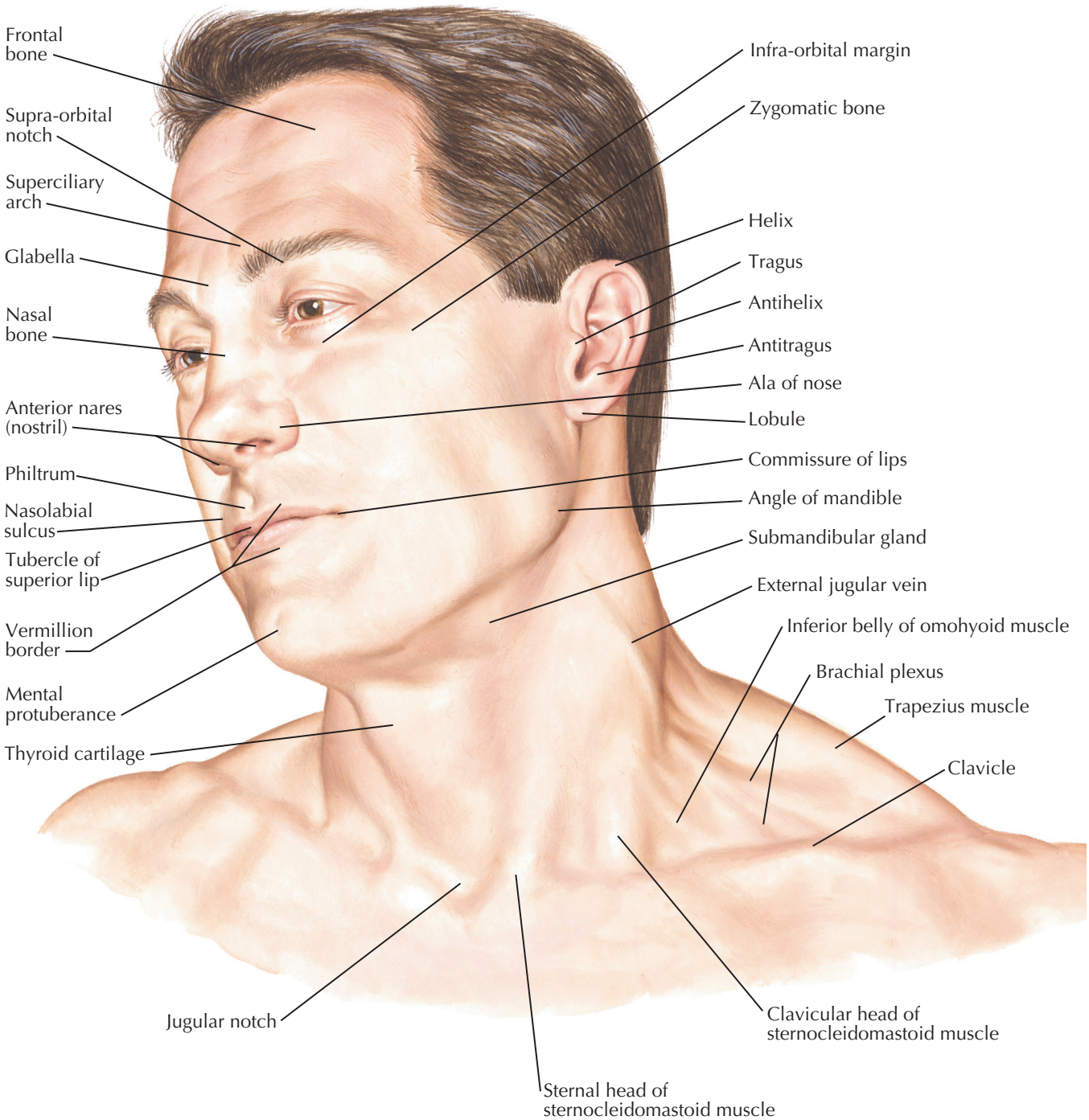
Regional Scans

Plates 150–151

150 Cranial Imaging (MRV and MRA)

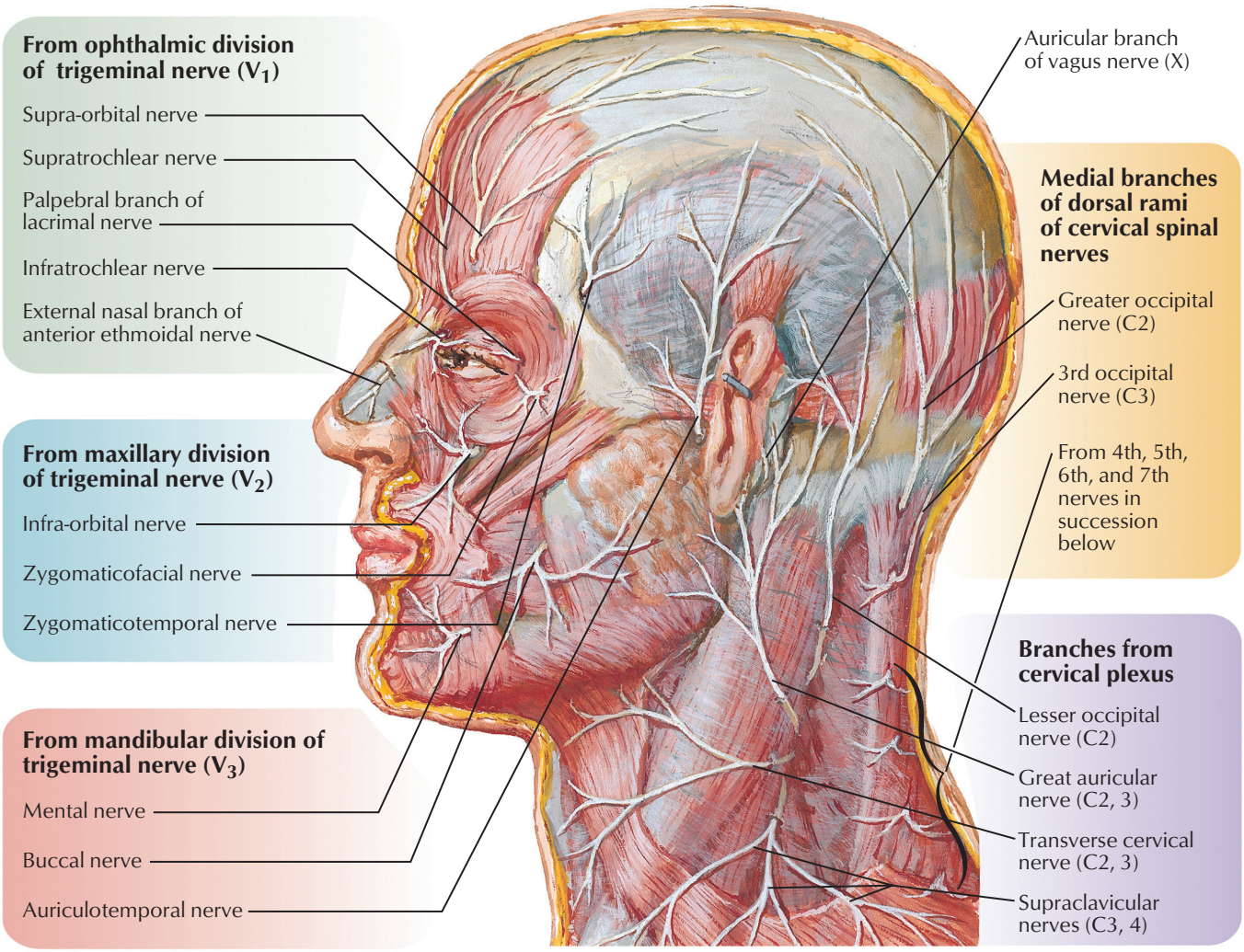
151 Cranial Imaging (MRI)

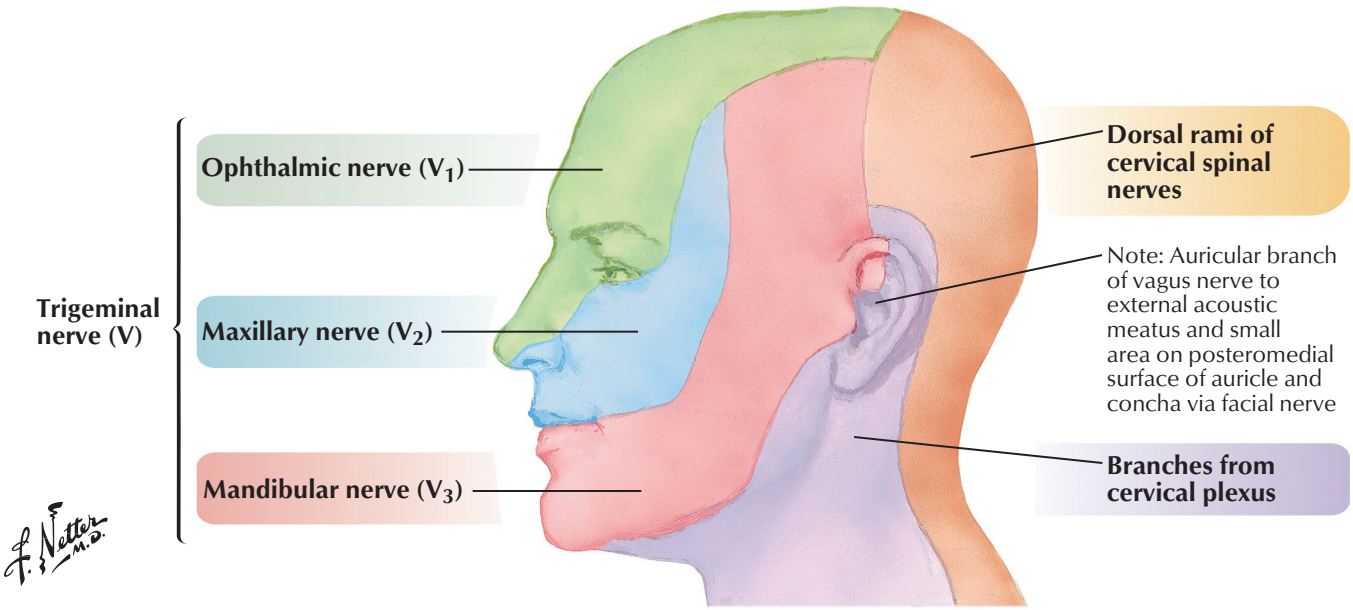
Muscle Tables


Frontal bone
Supra-orbital notch
Superciliary arch
Glabella
Nasal bone
Anterior nares (nostril)
Philtrum
Nasolabial sulcus
Tubercle of superior lip
Vermillion border
Mental protuberance
Thyroid cartilage
Jugular notch
Infra-orbital margin
Zygomatic bone
Helix
Tragus
Antihelix
Antitragus
Ala of nose
Lobule
Commissure of lips
Angle of mandible
Submandibular gland
External jugular vein
Inferior belly of omohyoid muscle
Brachial plexus
Trapezius muscle
Clavicle
Clavicular head of sternocleidomastoid muscle
Sternal head of sternocleidomastoid muscle
C. Machado M.D.

Cutaneous Nerves of Head and Neck

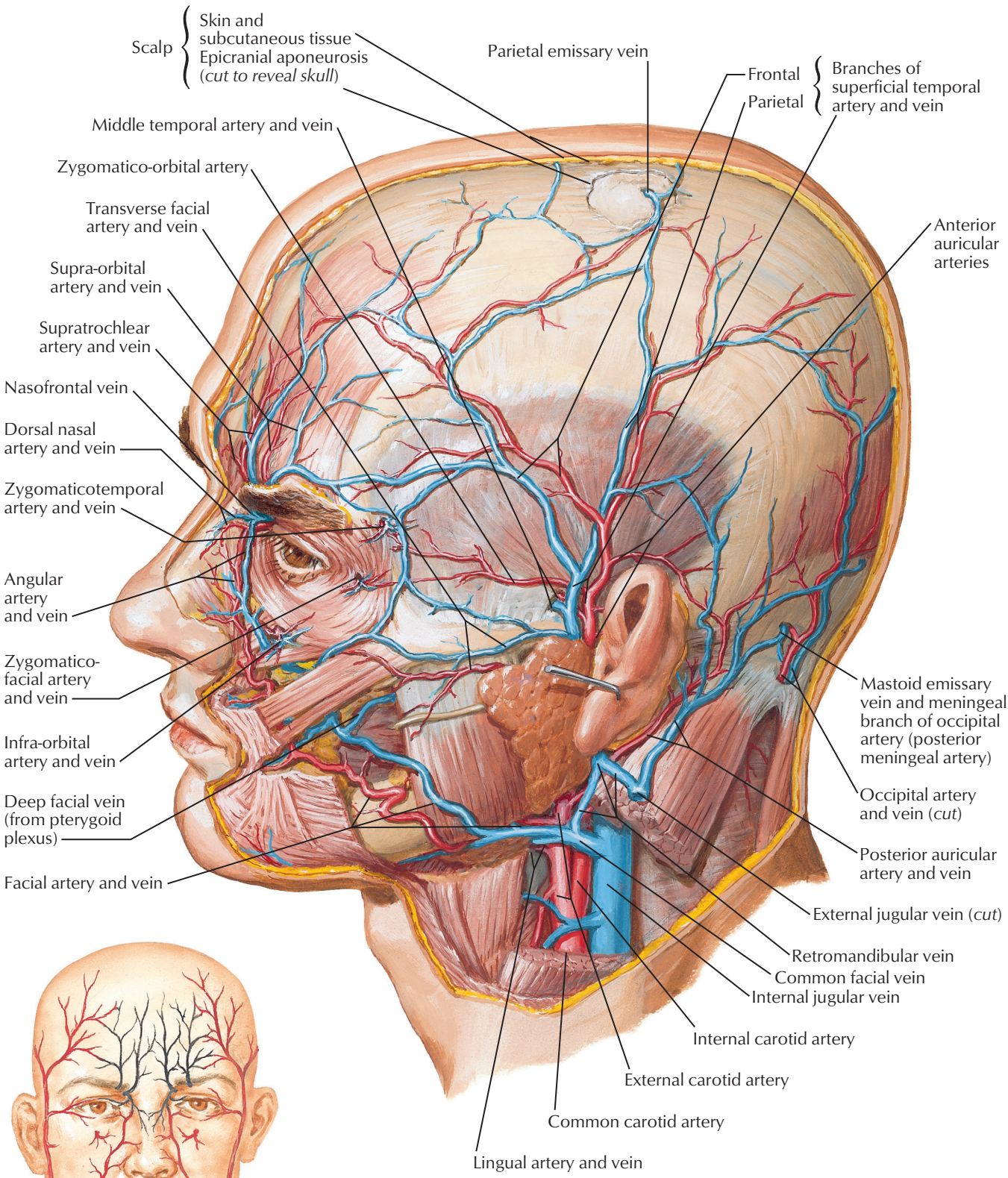
See also Plates 32, 35, 52

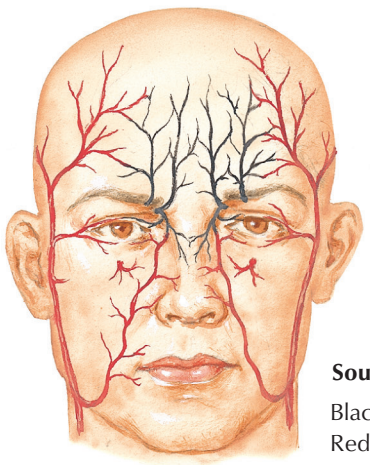




Superficial Arteries and Veins of Face and Scalp

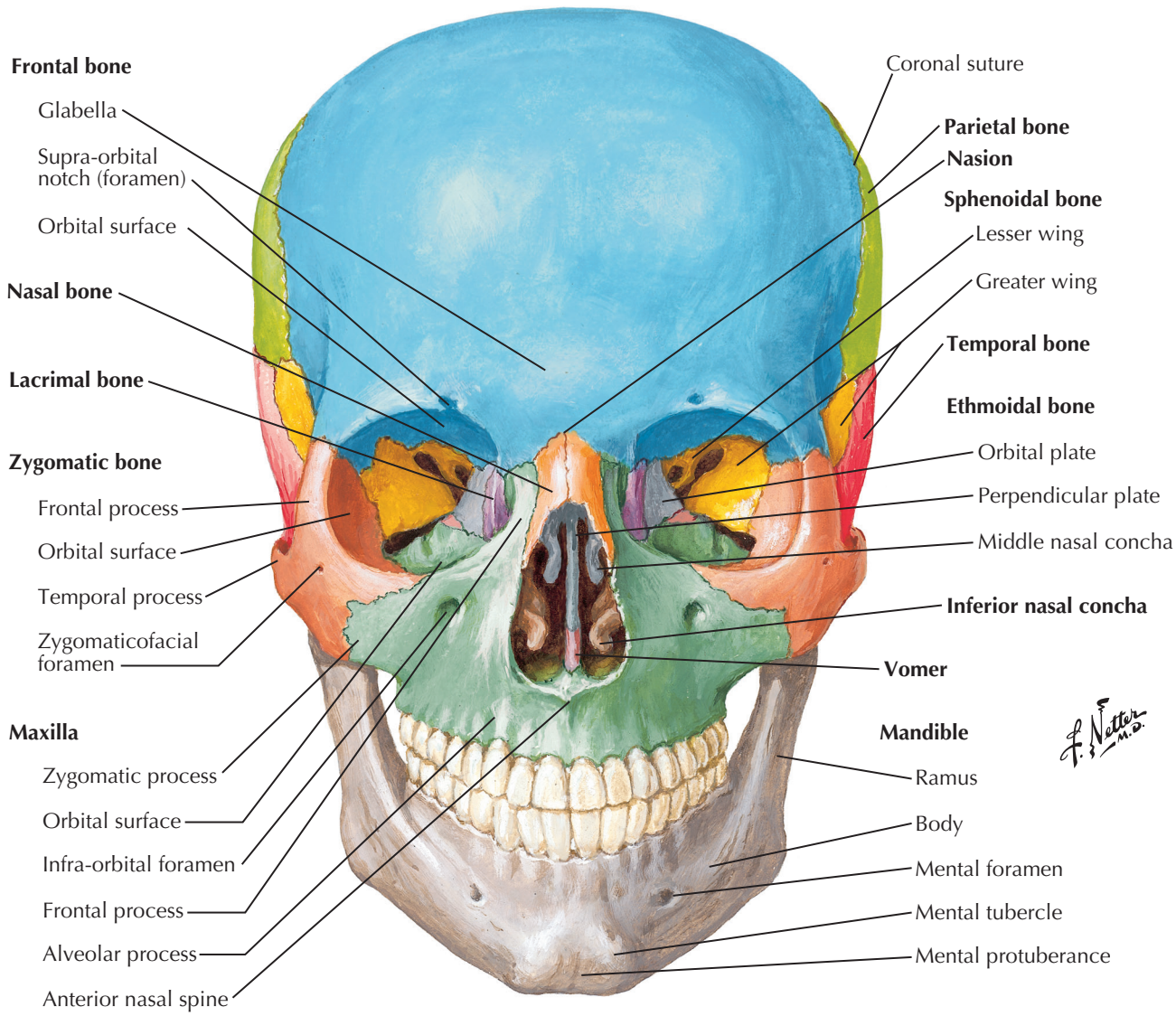
See also Plates 51, 72, 73



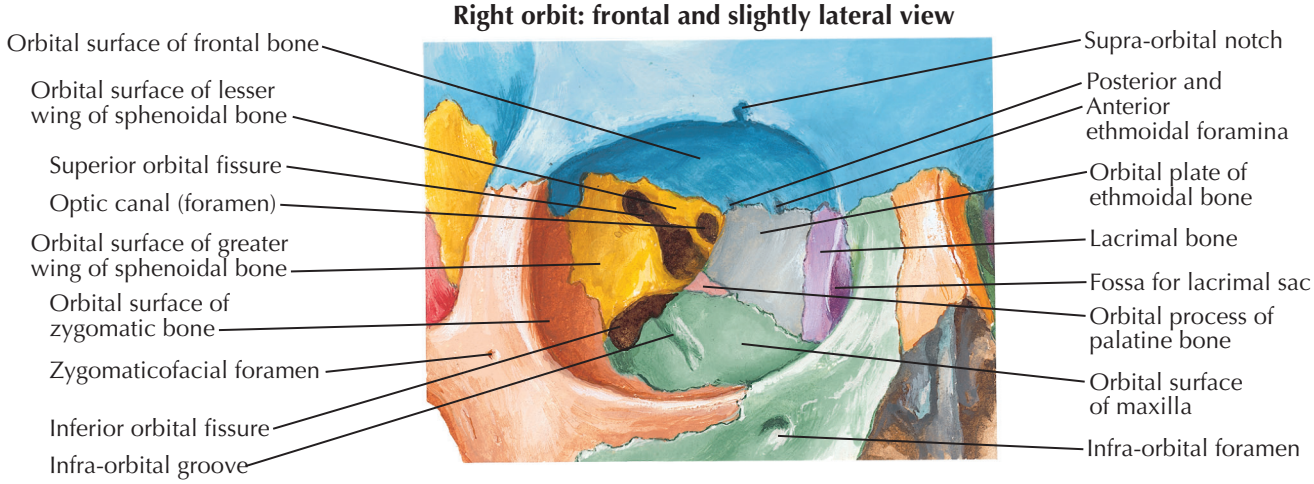


Sources of arterial supply of face

Black: from internal carotid artery (via ophthalmic artery)
Red: from external carotid artery

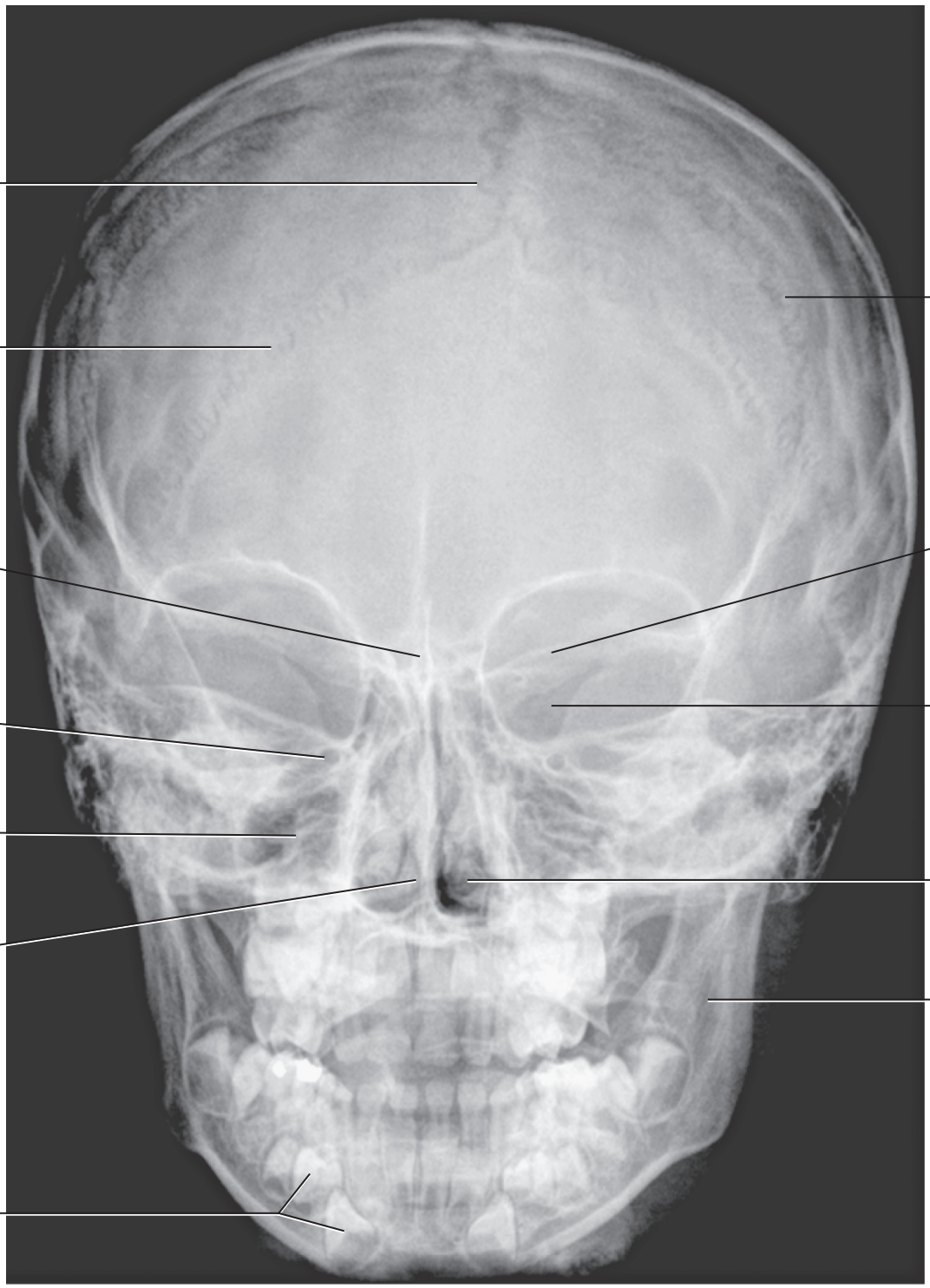


Right orbit: frontal and slightly lateral view



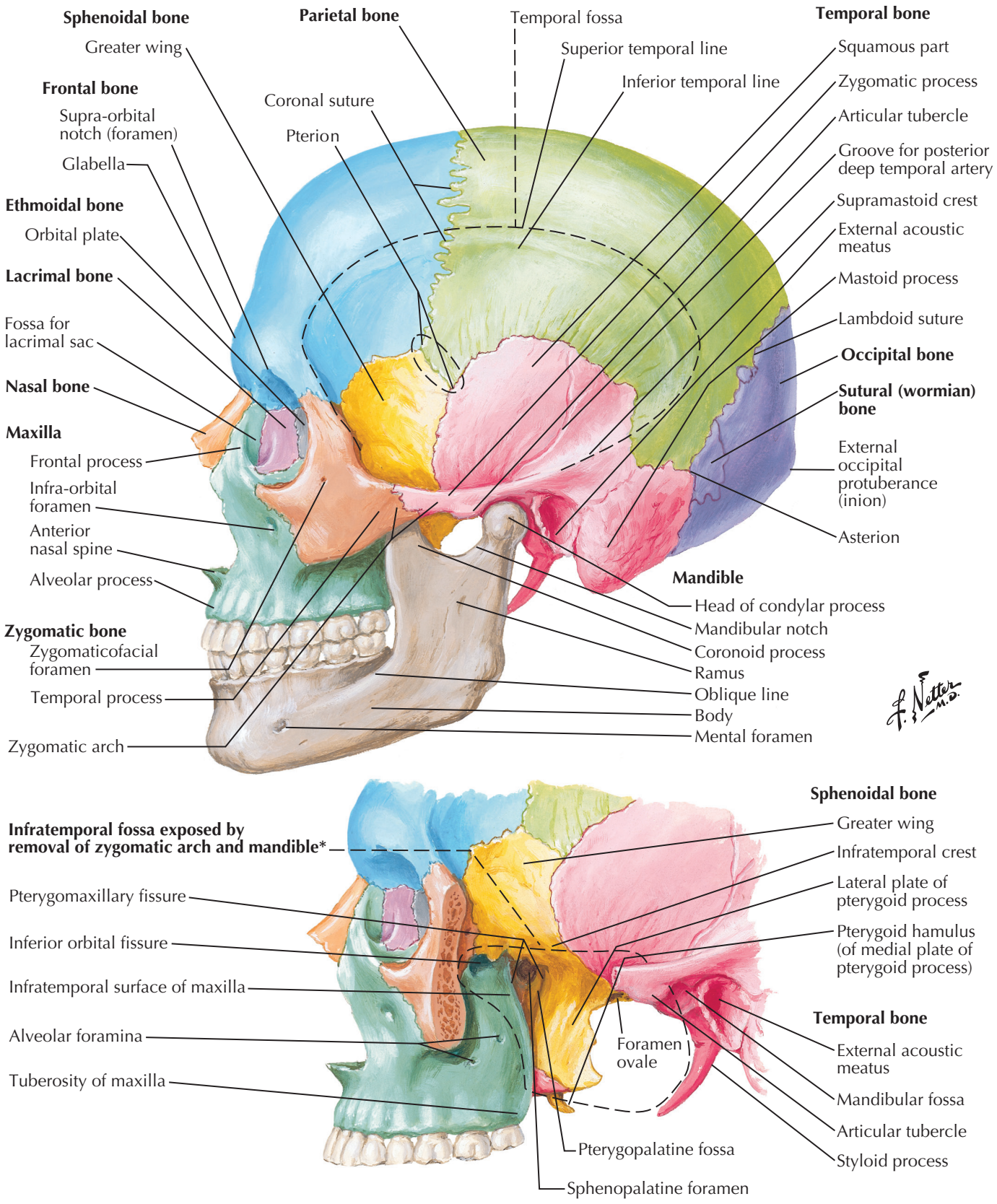
Skull: Anteroposterior Radiograph

See also Plate 4



Skull: Lateral View

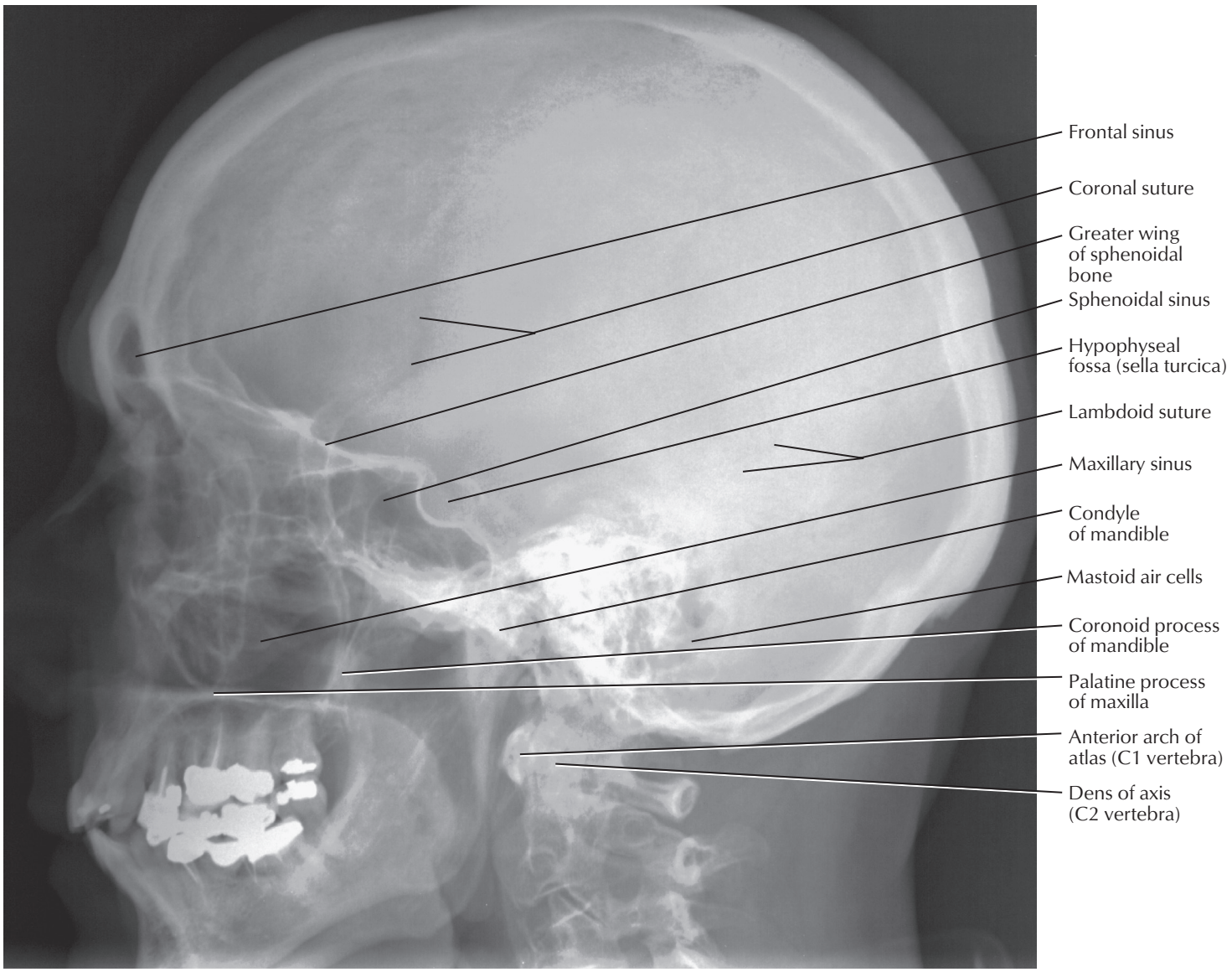
See also Plates 7, 8, 15



Superficially, mastoid process forms posterior boundary.

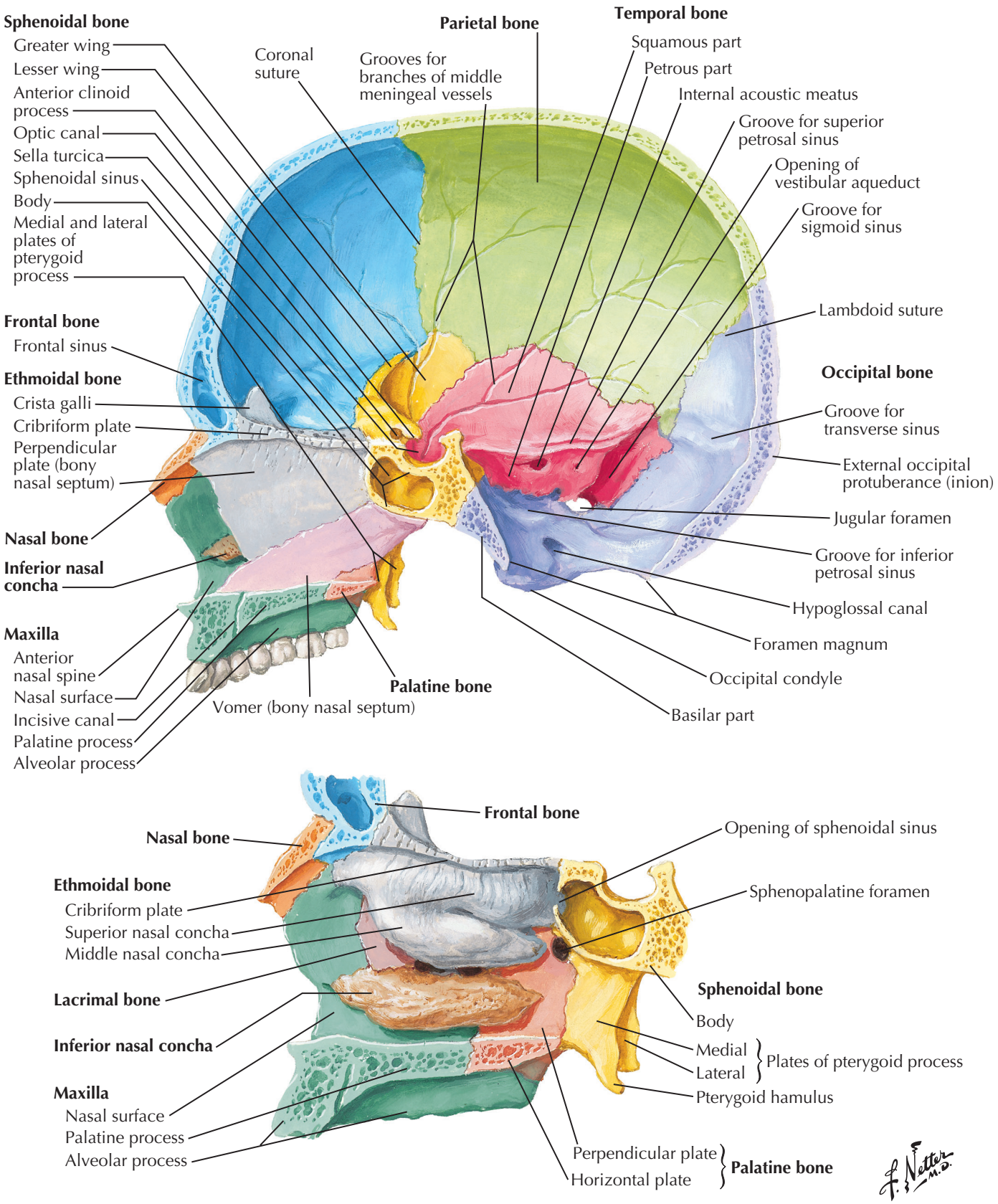
Skull: Lateral Radiograph

See also Plate 8



Skull: Midsagittal Section

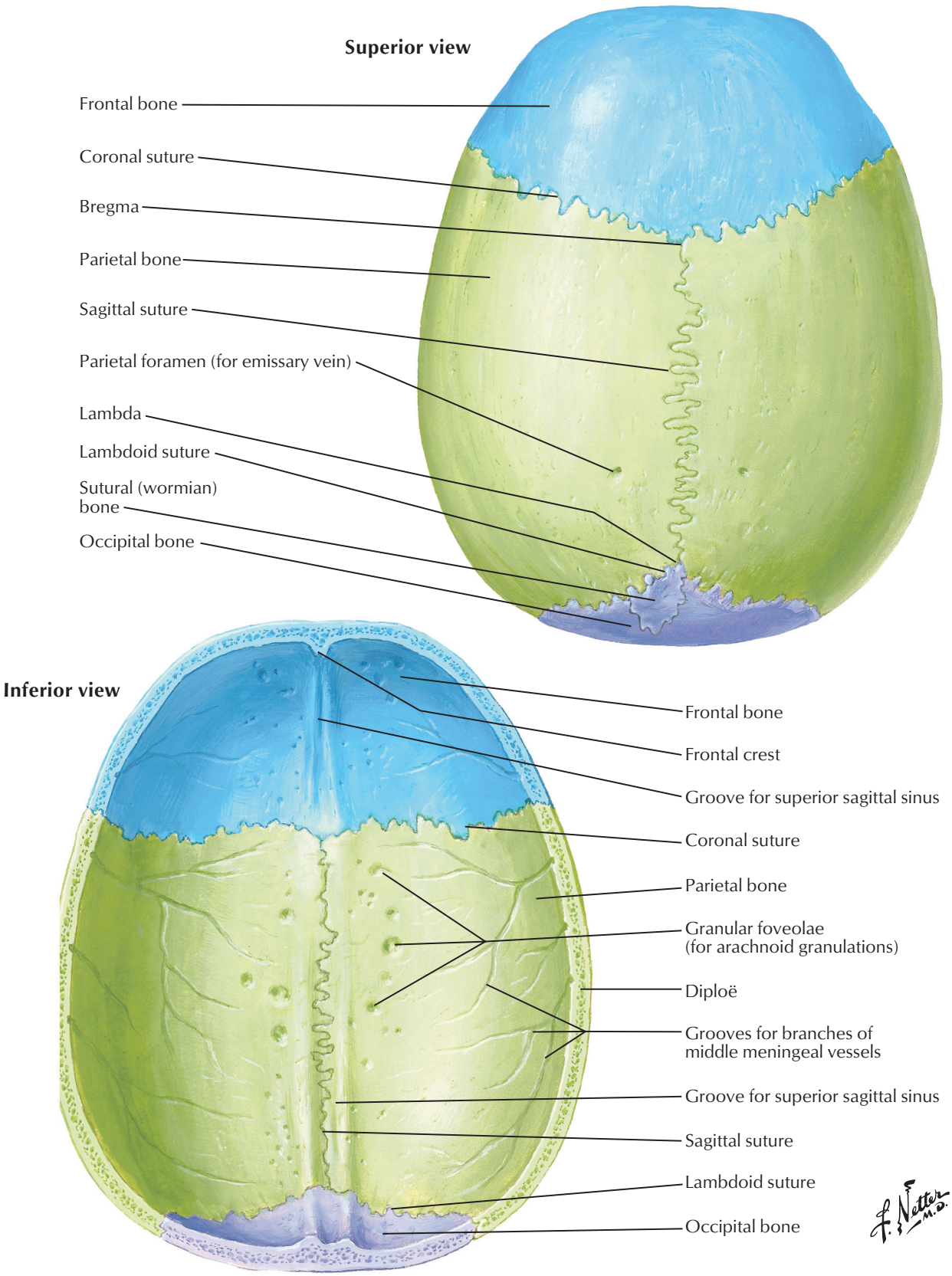
See also Plates 37, 39



View of lateral nasal wall with nasal septum removed

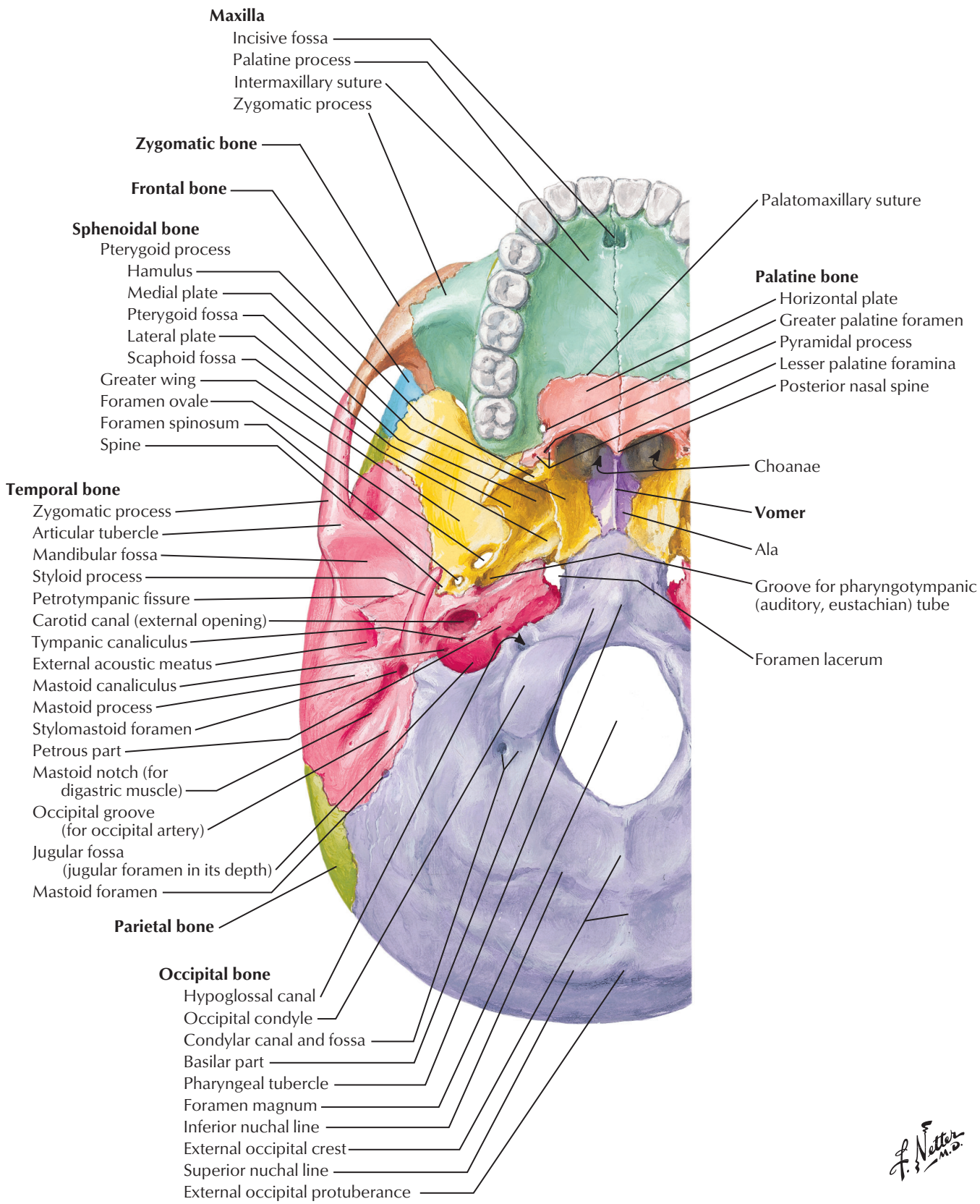
Calvaria

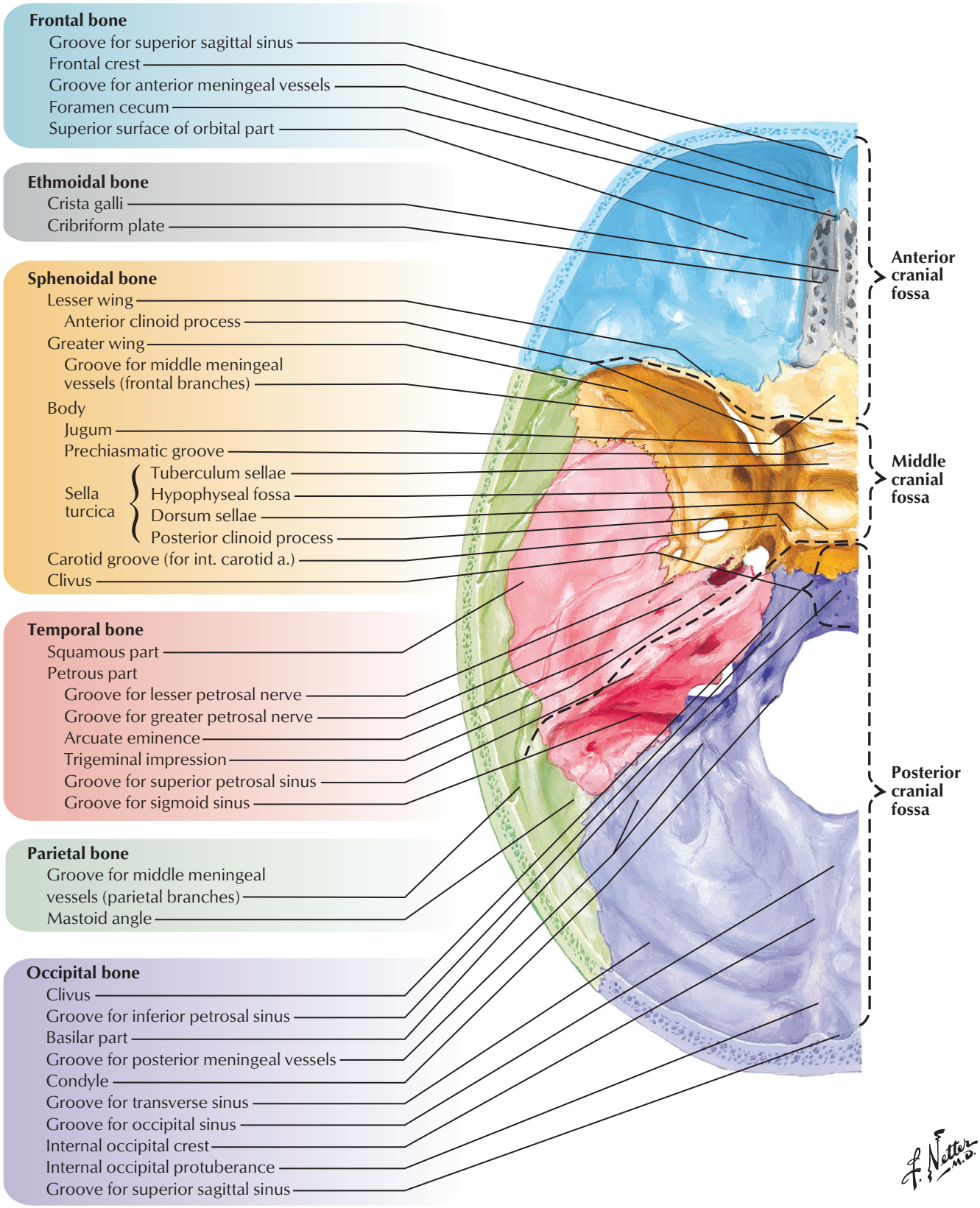
See also Plates 101, 102



Cranial Base: Inferior View

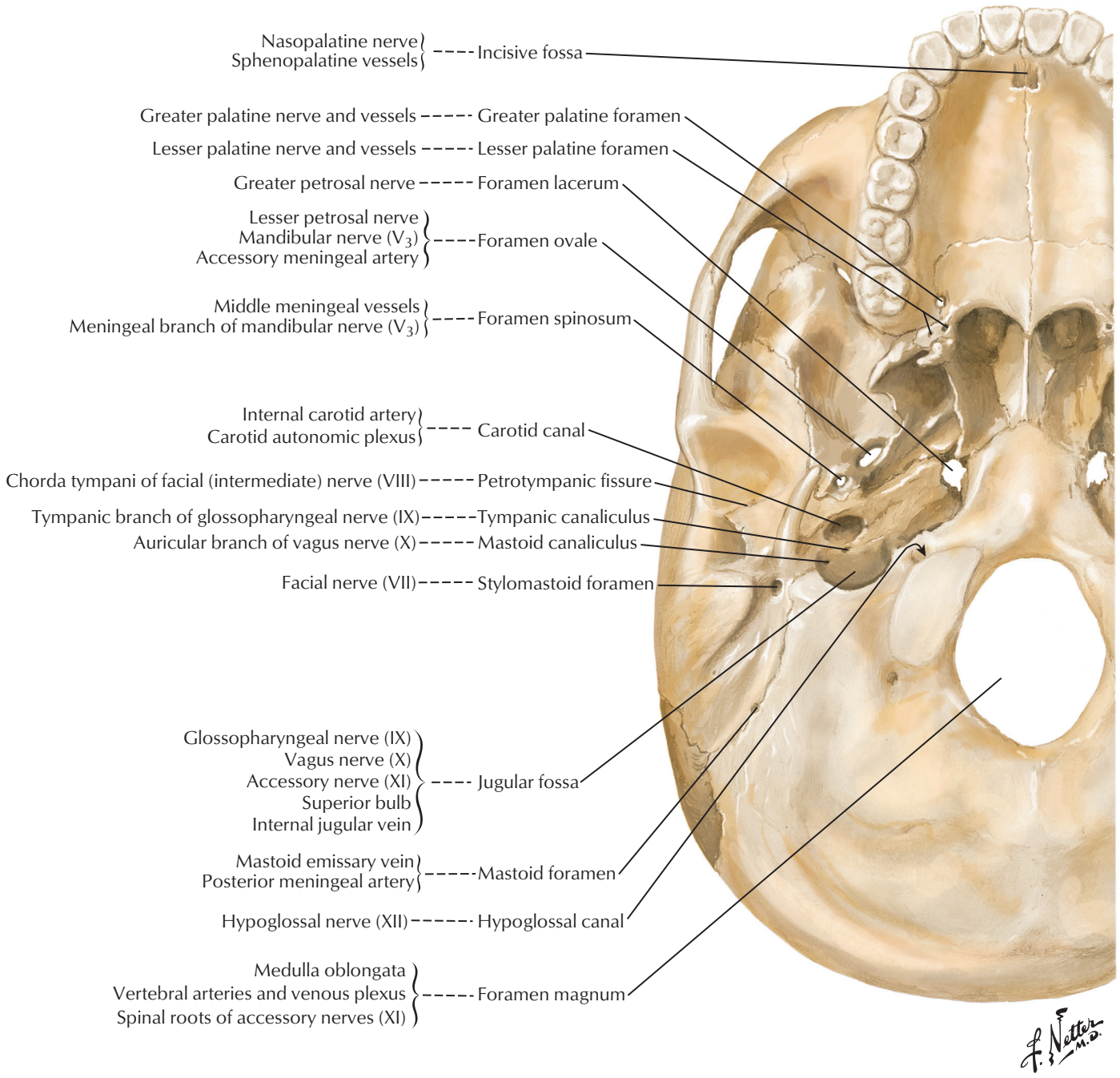
See also Plate 12




Frontal bone
Groove for superior sagittal sinus
Frontal crest
Groove for anterior meningeal vessels
Foramen cecum
Superior surface of orbital part
Ethmoidal bone
Crista galli
Cribriform plate
Sphenoidal bone
Lesser wing
Anterior clinoid process
Greater wing
Groove for middle meningeal vessels (frontal branches)
Body
Jugum
Prechiasmatic groove
Sella turcica
Tuberculum sellae
Hypophyseal fossa
Dorsum sellae
Posterior clinoid process
Carotid groove (for int. carotid a.)
Clivus
Temporal bone
Squamous part
Petrous part
Groove for lesser petrosal nerve
Groove for greater petrosal nerve
Arcuate eminence
Trigeminal impression
Groove for superior petrosal sinus
Groove for sigmoid sinus
Parietal bone
Groove for middle meningeal vessels (parietal branches)
Mastoid angle
Occipital bone
Clivus
Groove for inferior petrosal sinus
Basilar part
Groove for posterior meningeal vessels
Condyle
Groove for transverse sinus
Groove for occipital sinus
Internal occipital crest
Internal occipital protuberance
Groove for superior sagittal sinus
Anterior cranial fossa
Middle cranial fossa
Posterior cranial fossa

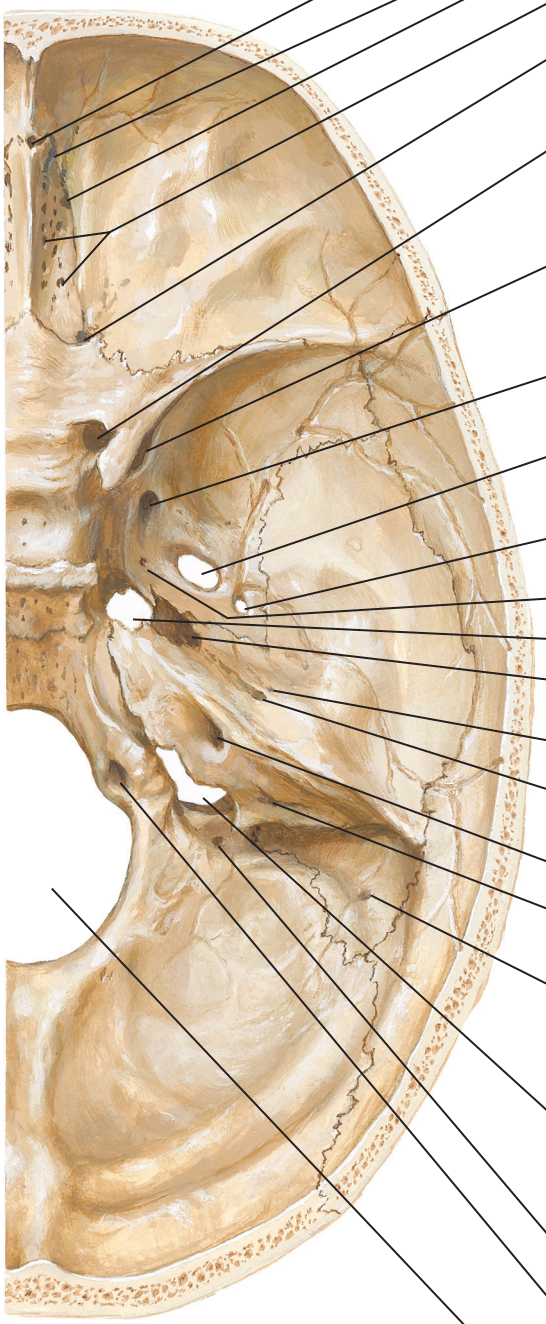
Foramina and Canals of Cranial Base: Inferior View

See also **Plate 10**



Foramina and Canals of Cranial Base: Superior View

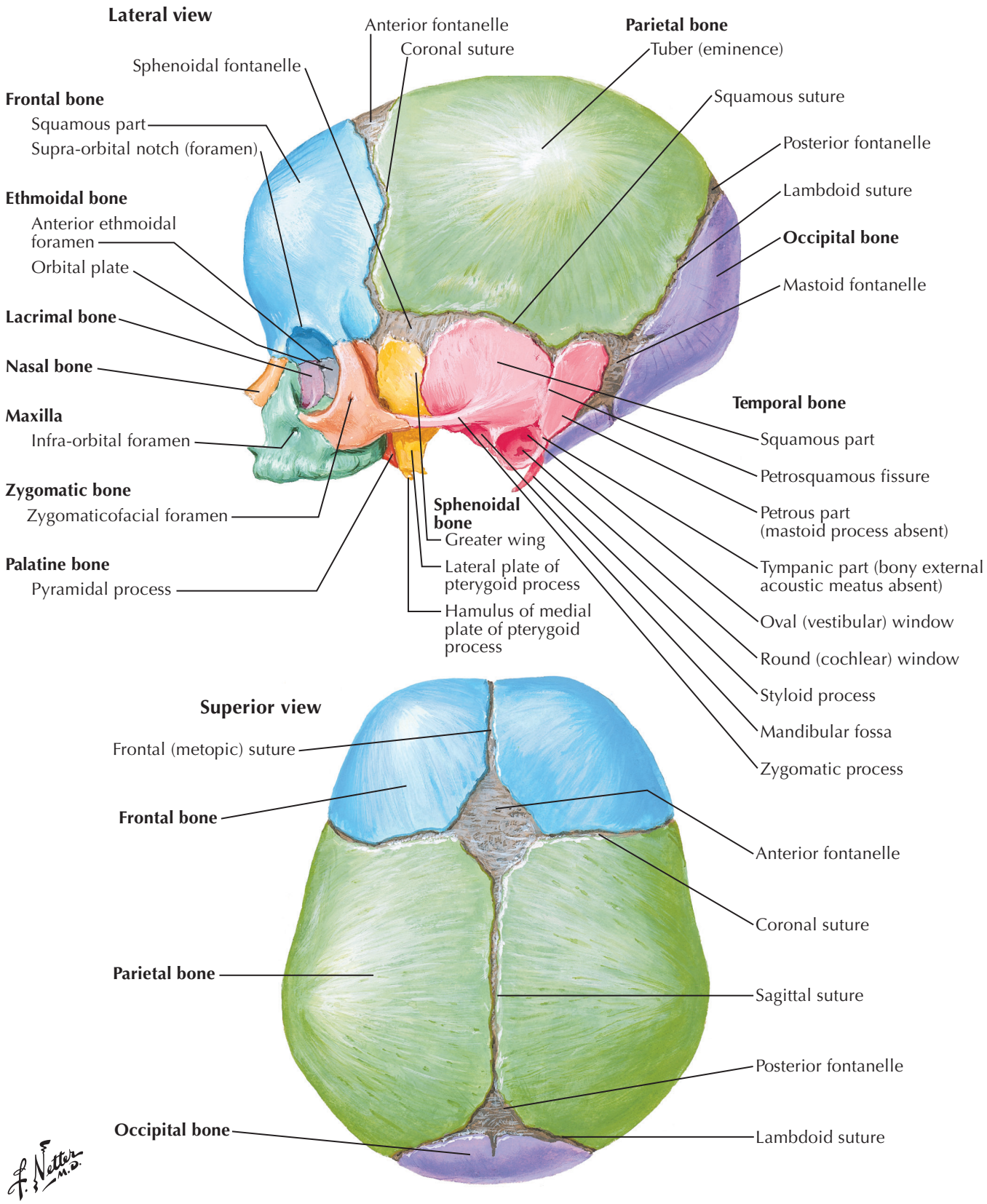
See also Plate 11

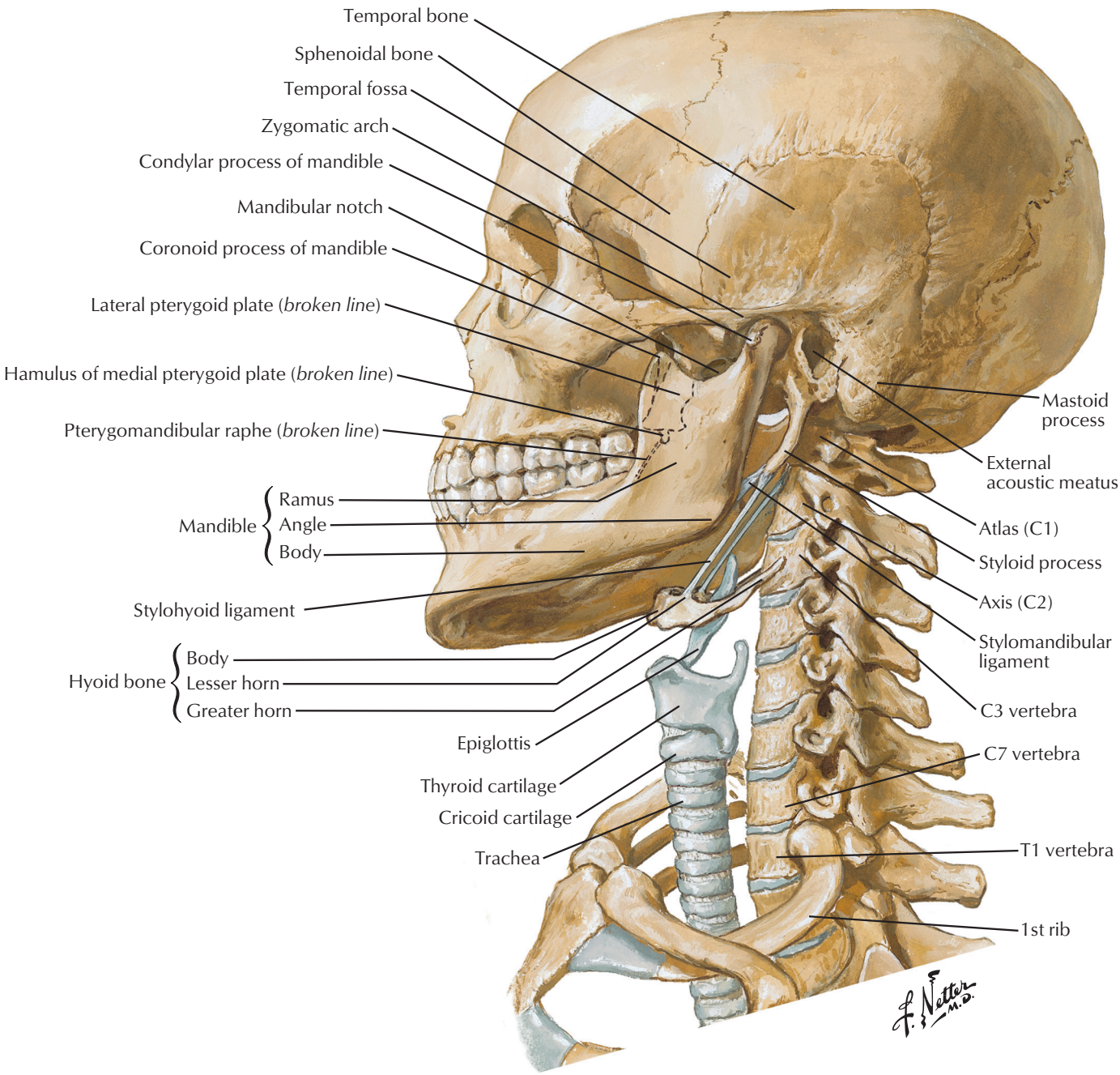


- Foramen cecum — Emissary vein to superior sagittal sinus
- Nasal slit — Anterior ethmoidal artery, vein, and nerve
- Anterior ethmoidal foramen — Anterior ethmoidal artery, vein, and nerve
- Foramina of cribriform plate — Olfactory nerves
- Posterior ethmoidal foramen — Posterior ethmoidal artery, vein, and nerve
- Optic canal — Optic nerve (II); Ophthalmic artery
- Superior orbital fissure — Oculomotor nerve (III); Trochlear nerve (IV); Lacrimal, frontal, and nasociliary branches of ophthalmic nerve (V_1); Abducent nerve (VI); Superior ophthalmic vein
- Foramen rotundum — Maxillary nerve (V_2)
- Foramen ovale — Mandibular nerve (V_3); Accessory meningeal artery; Lesser petrosal nerve
- Foramen spinosum — Middle meningeal artery and vein; Meningeal branch of mandibular nerve
- Sphenoidal emissary foramen (of Vesalius) (inconstant)
- Foramen lacerum — Greater petrosal nerve
- Carotid canal — Internal carotid artery; Internal carotid nerve plexus
- Hiatus for — Lesser petrosal nerve
- Hiatus for — Greater petrosal nerve
- Internal acoustic meatus — Facial nerve (VII); Vestibulocochlear nerve (VIII); Labyrinthine artery
- Opening of vestibular aqueduct — Endolymphatic duct
- Mastoid foramen (inconstant) — Emissary vein (and occasional branch of occipital artery)
- Jugular foramen — Inferior petrosal sinus; Glossopharyngeal nerve (IX); Vagus nerve (X); Accessory nerve (XI); Sigmoid sinus; Posterior meningeal artery
- Condylar canal (inconstant) — Emissary vein and meningeal branch of ascending pharyngeal artery
- Hypoglossal canal — Hypoglossal nerve (XII)
- Foramen magnum — Medulla oblongata; Meninges; Vertebral arteries; Meningeal branches of vertebral arteries; Spinal roots of accessory nerves

Skull of Newborn

See also Plate 6

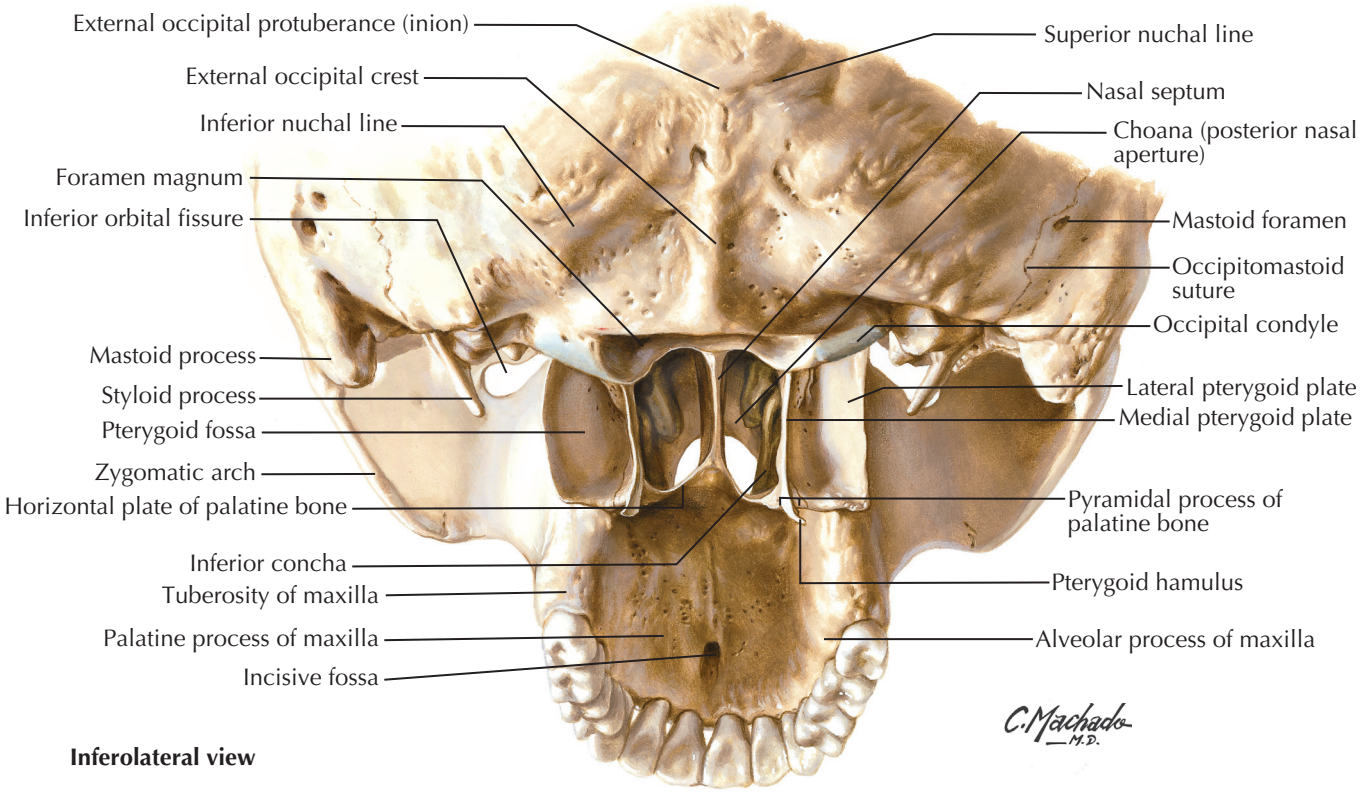



Temporal bone
Sphenoidal bone
Temporal fossa
Zygomatic arch
Condylar process of mandible
Mandibular notch
Coronoid process of mandible
Lateral pterygoid plate (broken line)
Hamulus of medial pterygoid plate (broken line)
Pterygomandibular raphe (broken line)
Mandible
Ramus
Angle
Body
Stylohyoid ligament
Hyoid bone
Body
Lesser horn
Greater horn
Epiglottis
Thyroid cartilage
Cricoid cartilage
Trachea
Mastoid process
External acoustic meatus
Atlas (C1)
Styloid process
Axis (C2)
Stylomandibular ligament
C3 vertebra
C7 vertebra
T1 vertebra
1st rib
F. Netter M.D.

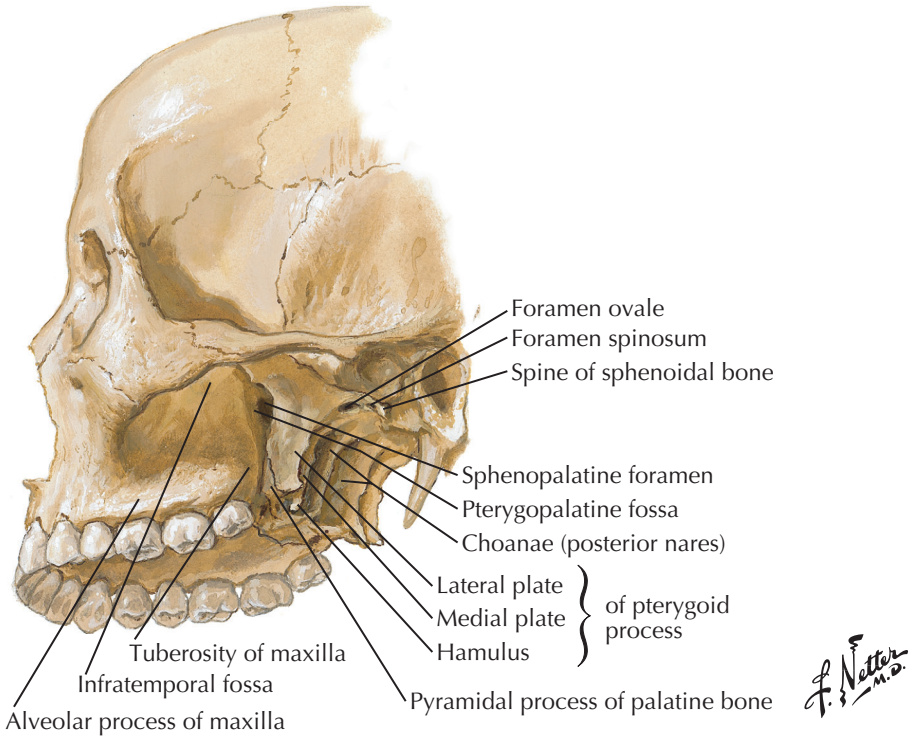
Pterygoid Fossae: Posterior and Inferolateral Views

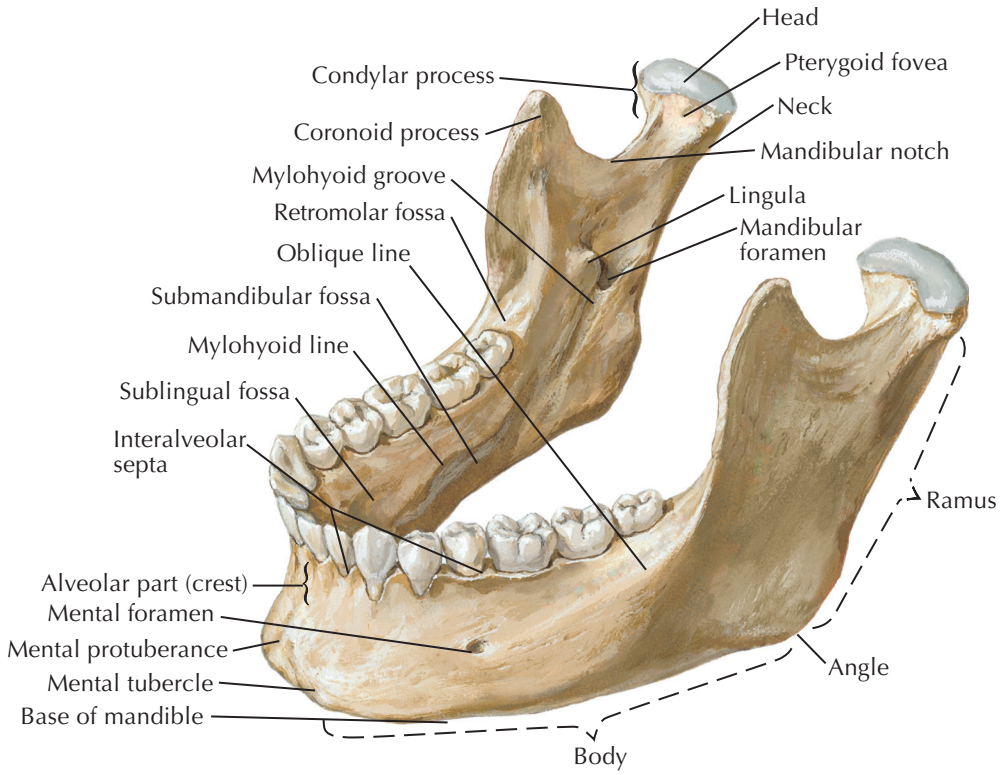
See also Plates 39, 40, 41

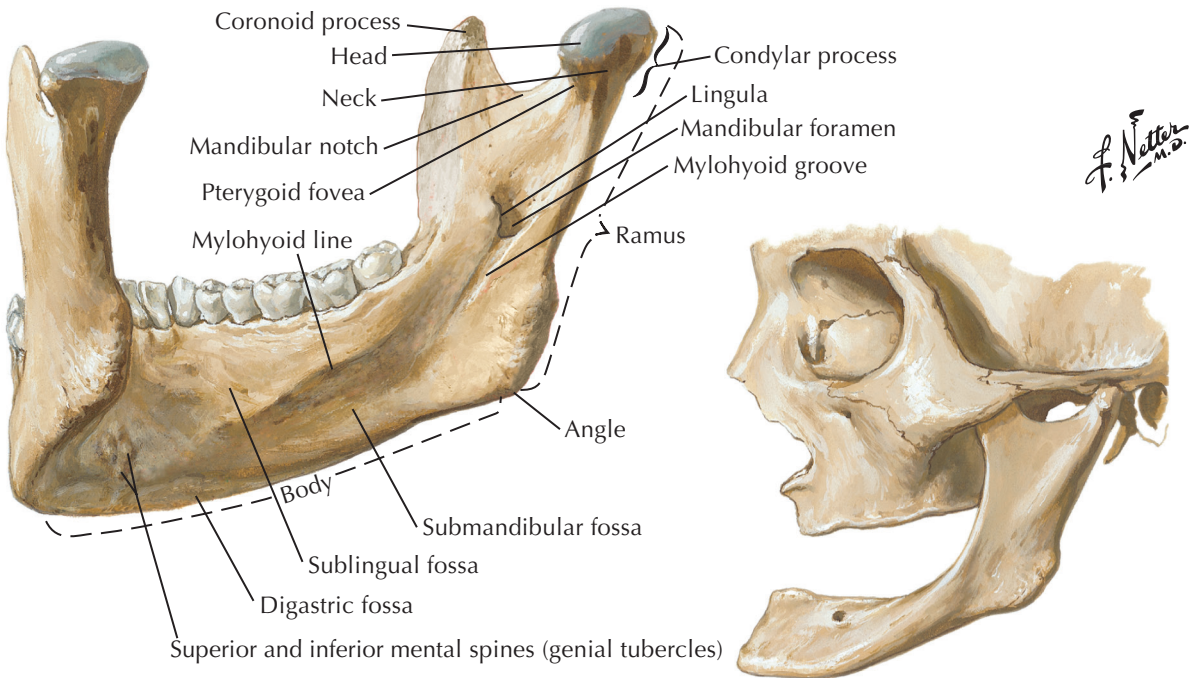
Posterior view



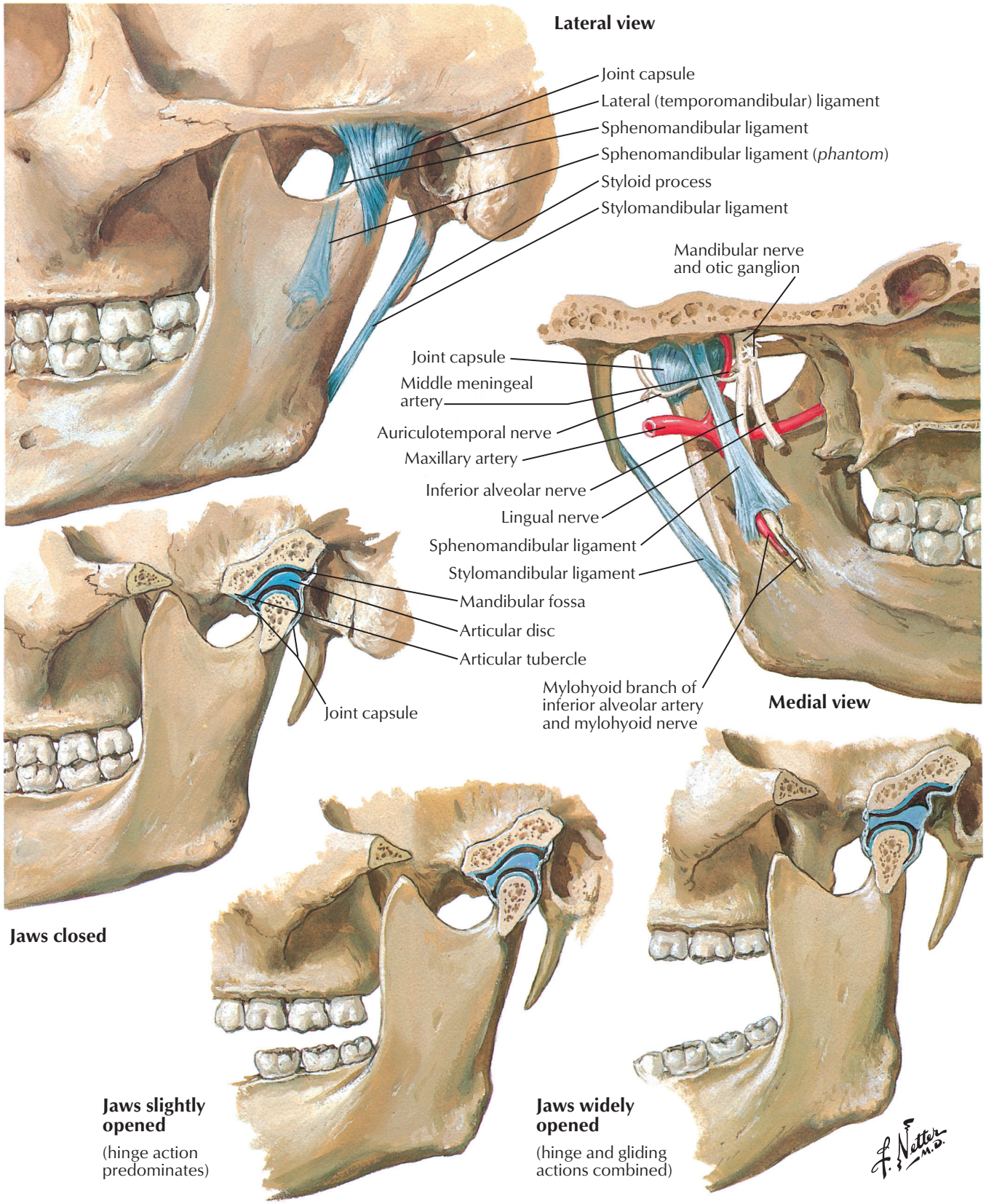
Inferolateral view

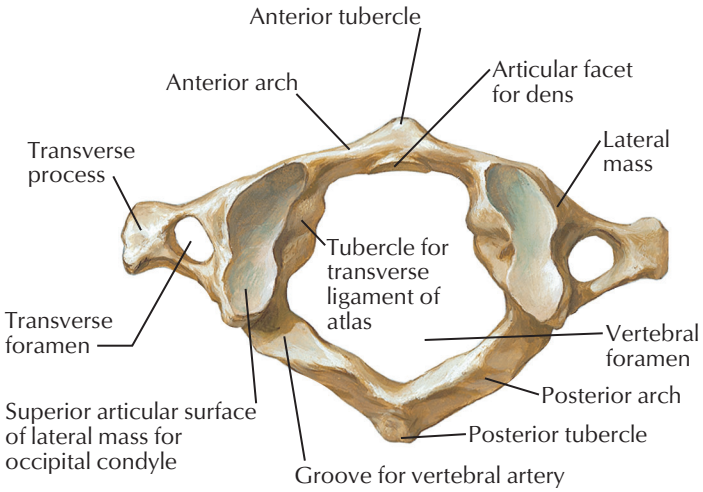




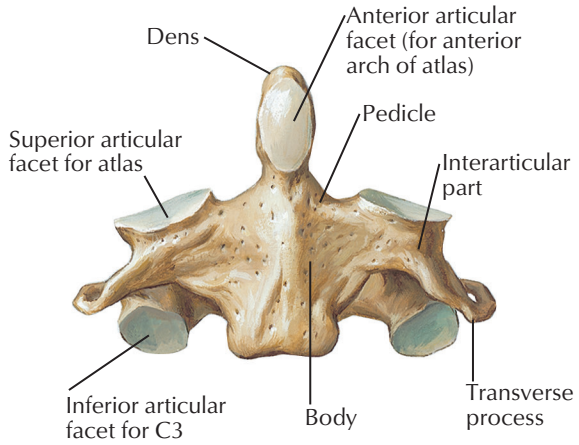


Mandible of aged person (edentulous)

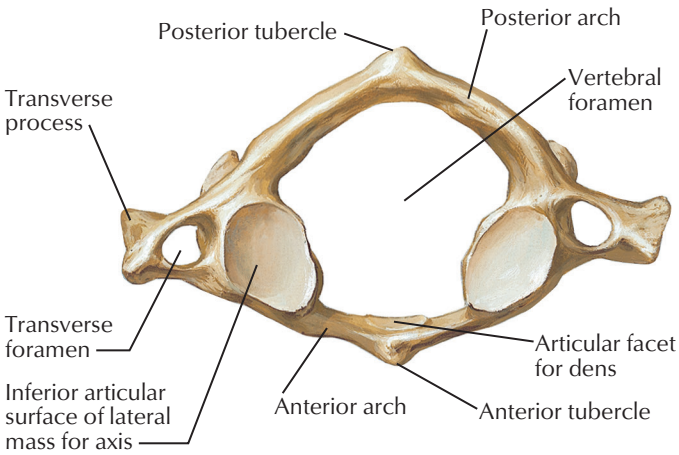

Lateral view
Joint capsule
Lateral (temporomandibular) ligament
Sphenomandibular ligament
Sphenomandibular ligament (*phantom*)
Styloid process
Stylomandibular ligament
Mandibular nerve and otic ganglion
Joint capsule
Middle meningeal artery
Auriculotemporal nerve
Maxillary artery
Inferior alveolar nerve
Lingual nerve
Sphenomandibular ligament
Stylomandibular ligament
Mylohyoid branch of inferior alveolar artery and mylohyoid nerve
Medial view
Mandibular fossa
Articular disc
Articular tubercle
Joint capsule
Jaws closed
Jaws slightly opened
(hinge action predominates)
Jaws widely opened
(hinge and gliding actions combined)



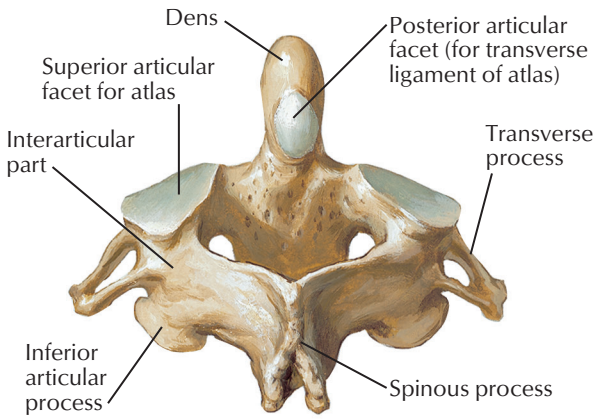
Atlas (C1): superior view



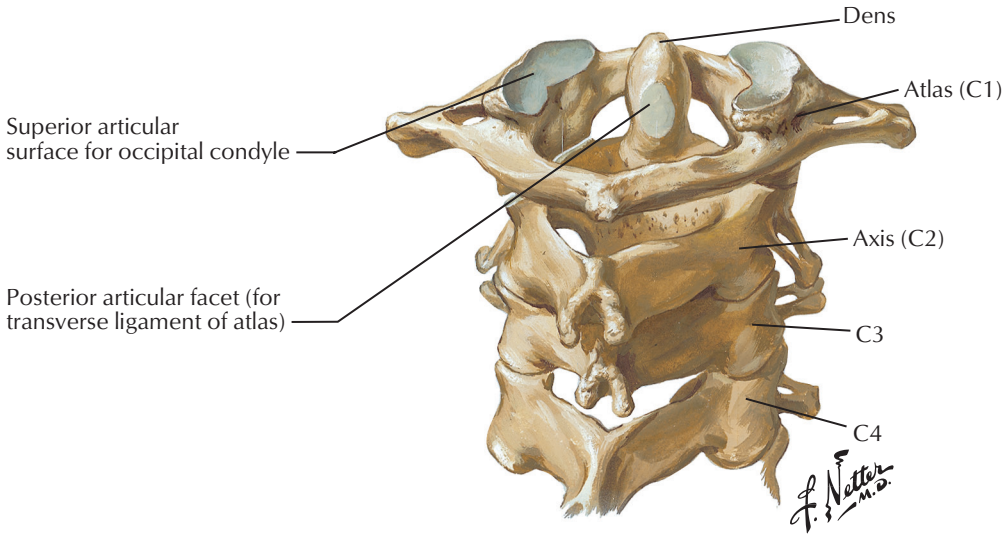
Axis (C2): anterior view



Atlas (C1): inferior view



Axis (C2): posterosuperior view

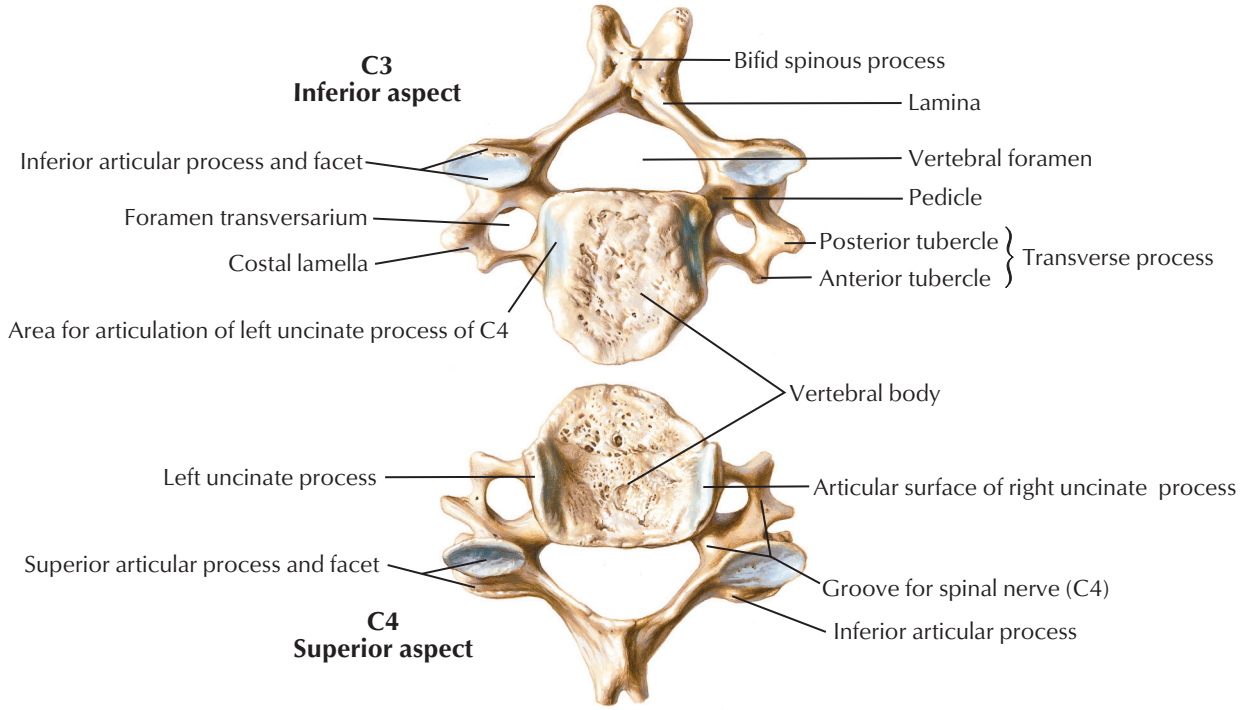


Upper cervical vertebrae, assembled: posterosuperior view

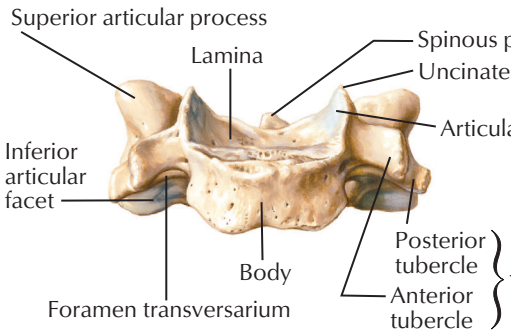
Cervical Vertebrae (continued)

See also Plates 21, 22

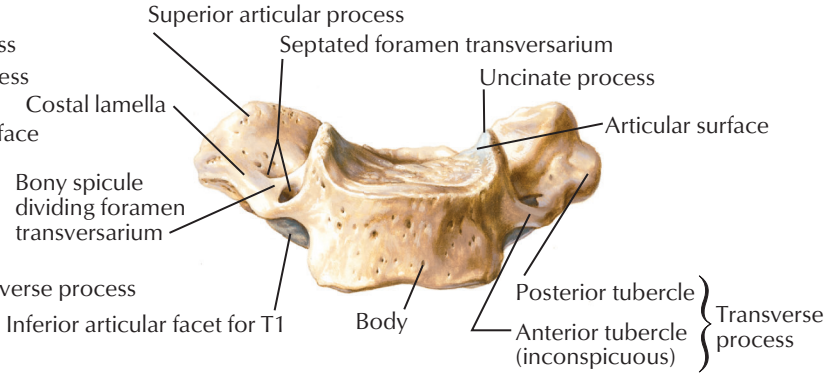
Inferior aspect of C3 and superior aspect of C4 showing the sites of the facet and uncovertebral articulations



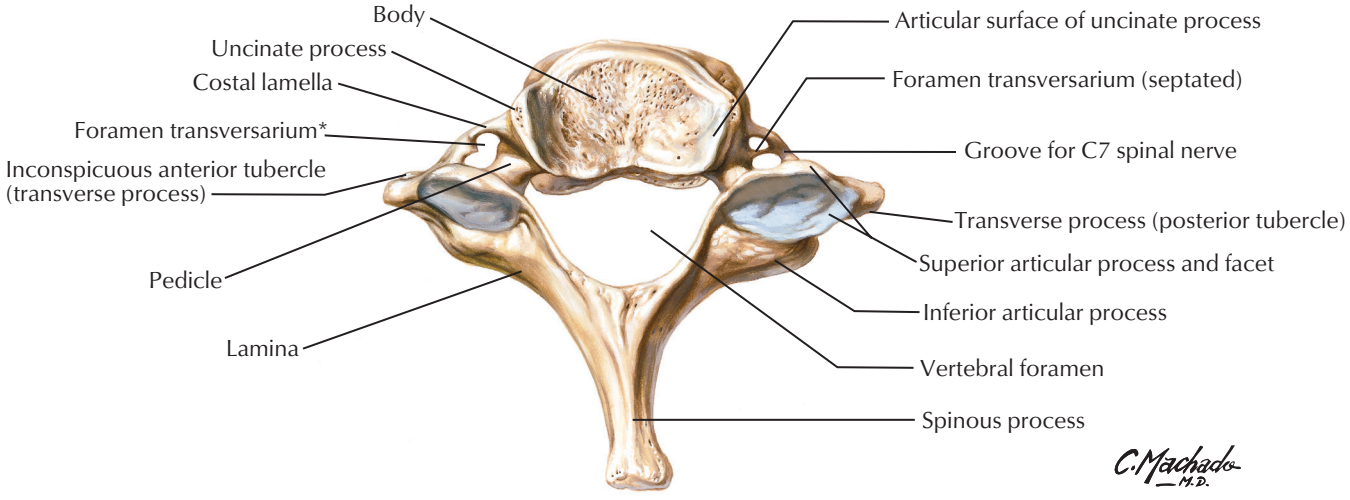
4th cervical vertebra: anterior view



7th cervical vertebra: anterior view

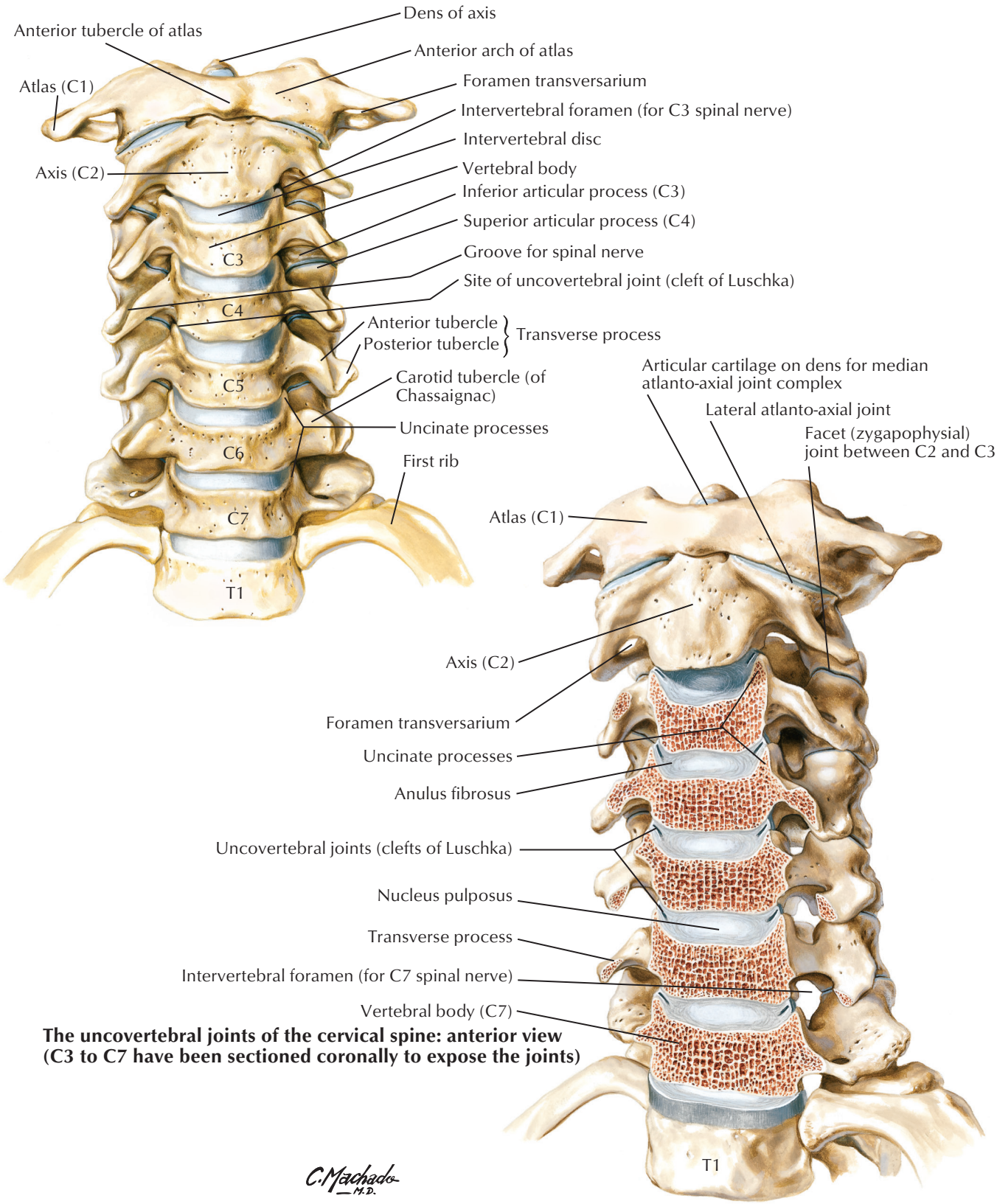


7th cervical vertebra (vertebra prominens): superior view

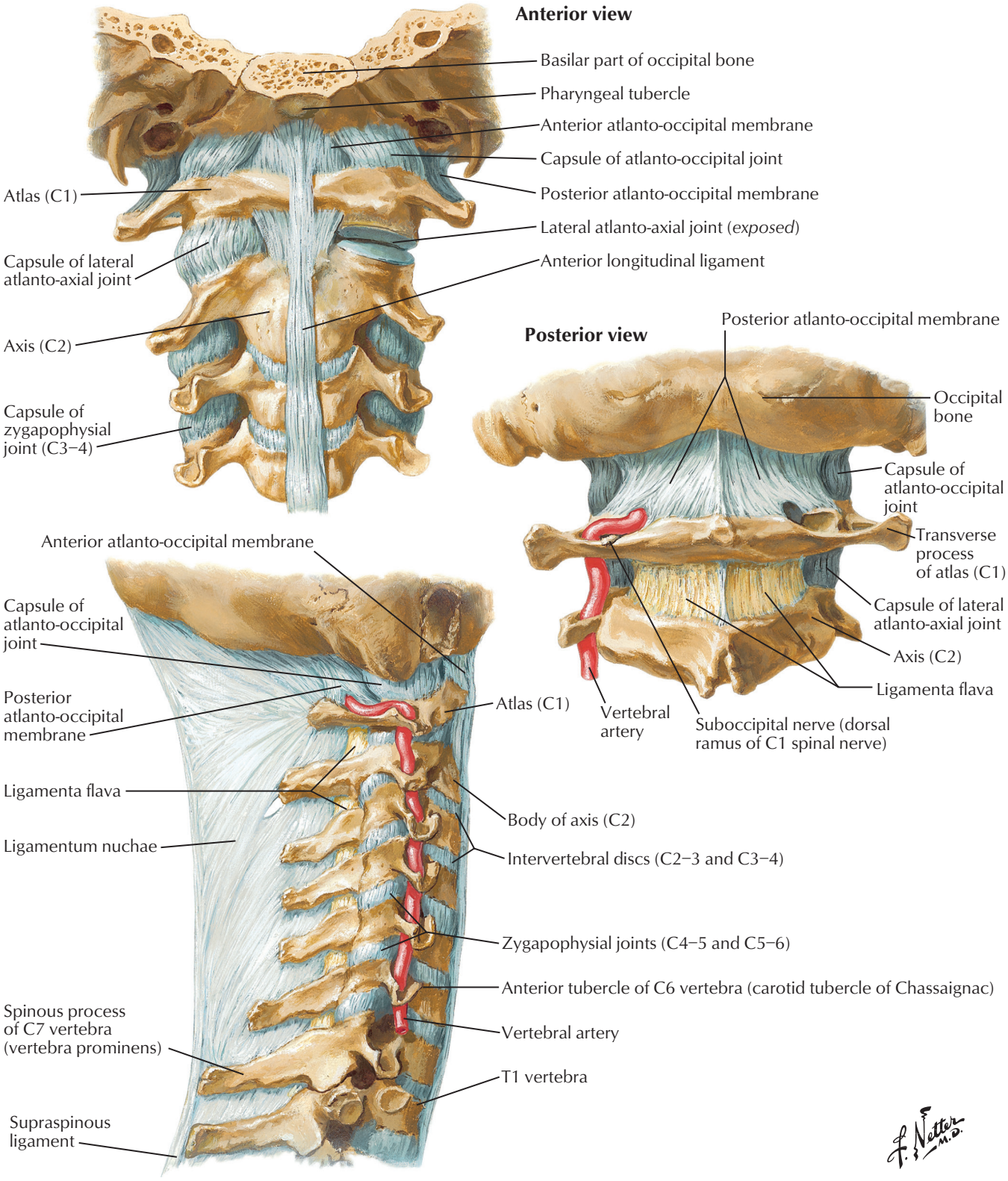


**The foramina transversaria of C7 transmit vertebral veins, but usually not the vertebral artery, and are asymmetrical in this specimen.*

Cervical vertebrae: anterior view

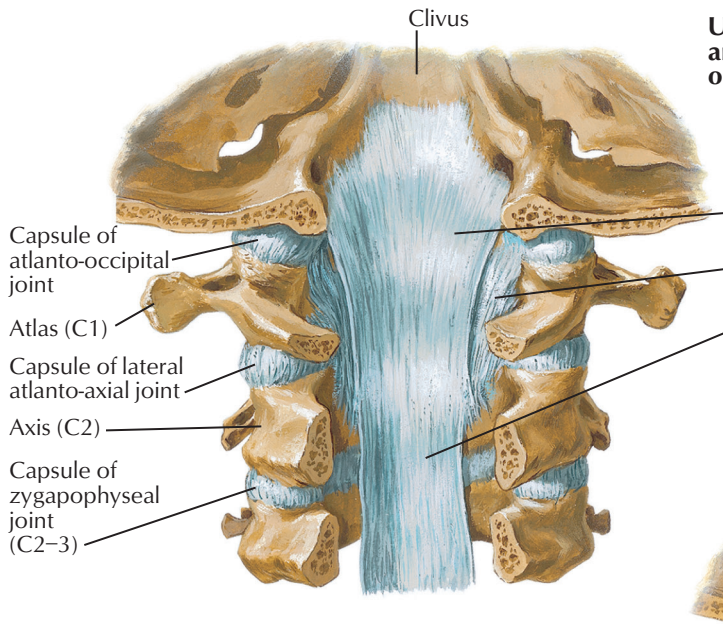


The uncovertebral joints of the cervical spine: anterior view (C3 to C7 have been sectioned coronally to expose the joints)

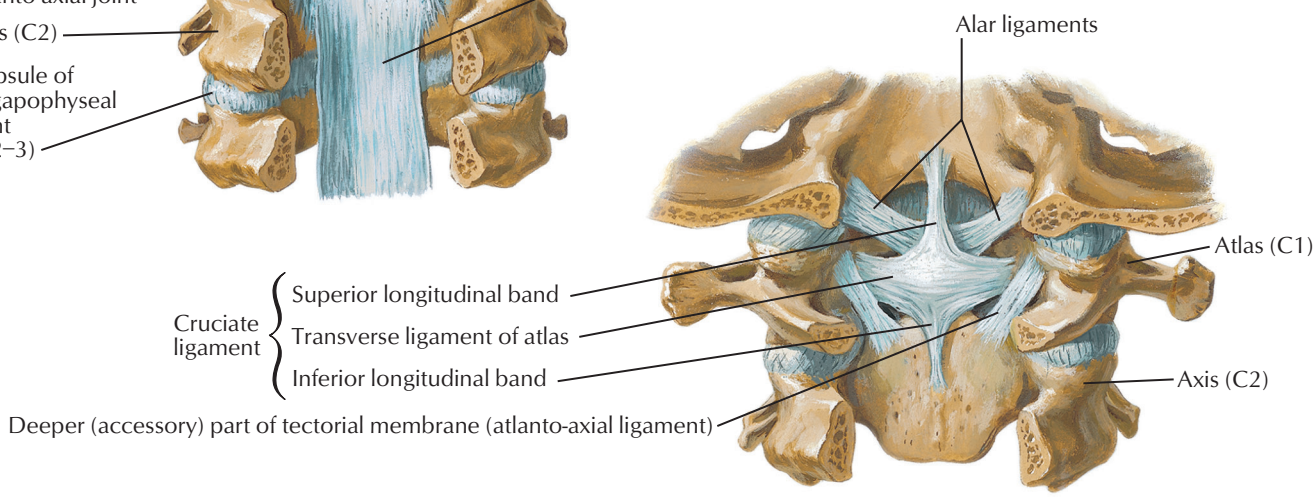

Anterior view
Basilar part of occipital bone
Pharyngeal tubercle
Anterior atlanto-occipital membrane
Capsule of atlanto-occipital joint
Posterior atlanto-occipital membrane
Lateral atlanto-axial joint (exposed)
Anterior longitudinal ligament
Atlas (C1)
Capsule of lateral atlanto-axial joint
Axis (C2)
Capsule of zygapophysial joint (C3–4)
Posterior view
Posterior atlanto-occipital membrane
Occipital bone
Capsule of atlanto-occipital joint
Transverse process of atlas (C1)
Capsule of lateral atlanto-axial joint
Axis (C2)
Ligamenta flava
Vertebral artery
Suboccipital nerve (dorsal ramus of C1 spinal nerve)
Anterior atlanto-occipital membrane
Capsule of atlanto-occipital joint
Posterior atlanto-occipital membrane
Atlas (C1)
Ligamenta flava
Ligamentum nuchae
Body of axis (C2)
Intervertebral discs (C2–3 and C3–4)
Zygapophysial joints (C4–5 and C5–6)
Anterior tubercle of C6 vertebra (carotid tubercle of Chassaignac)
Vertebral artery
T1 vertebra
Spinous process of C7 vertebra (vertebra prominens)
Supraspinous ligament
Right lateral view

Internal Craniocervical Ligaments

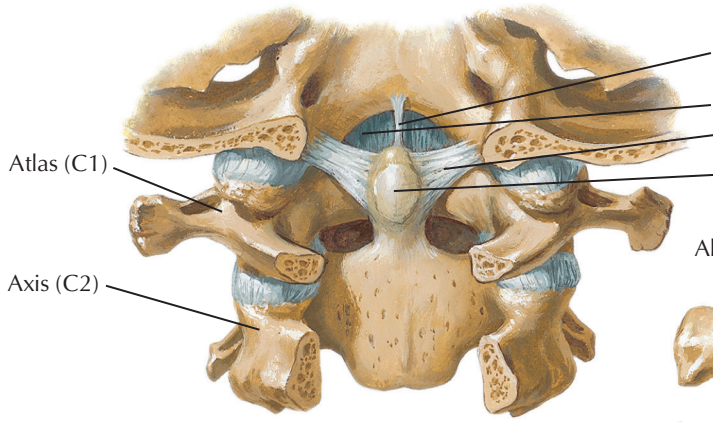
See also Plates 46, 124



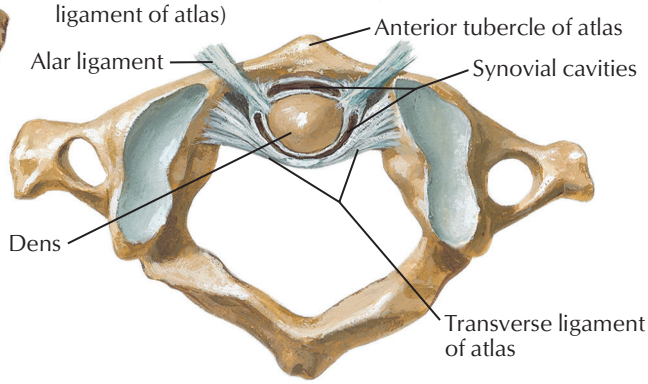
Upper part of vertebral canal with spinous processes and parts of vertebral arches removed to expose ligaments on posterior vertebral bodies: posterior view



Principal part of tectorial membrane removed to expose deeper ligaments: posterior view



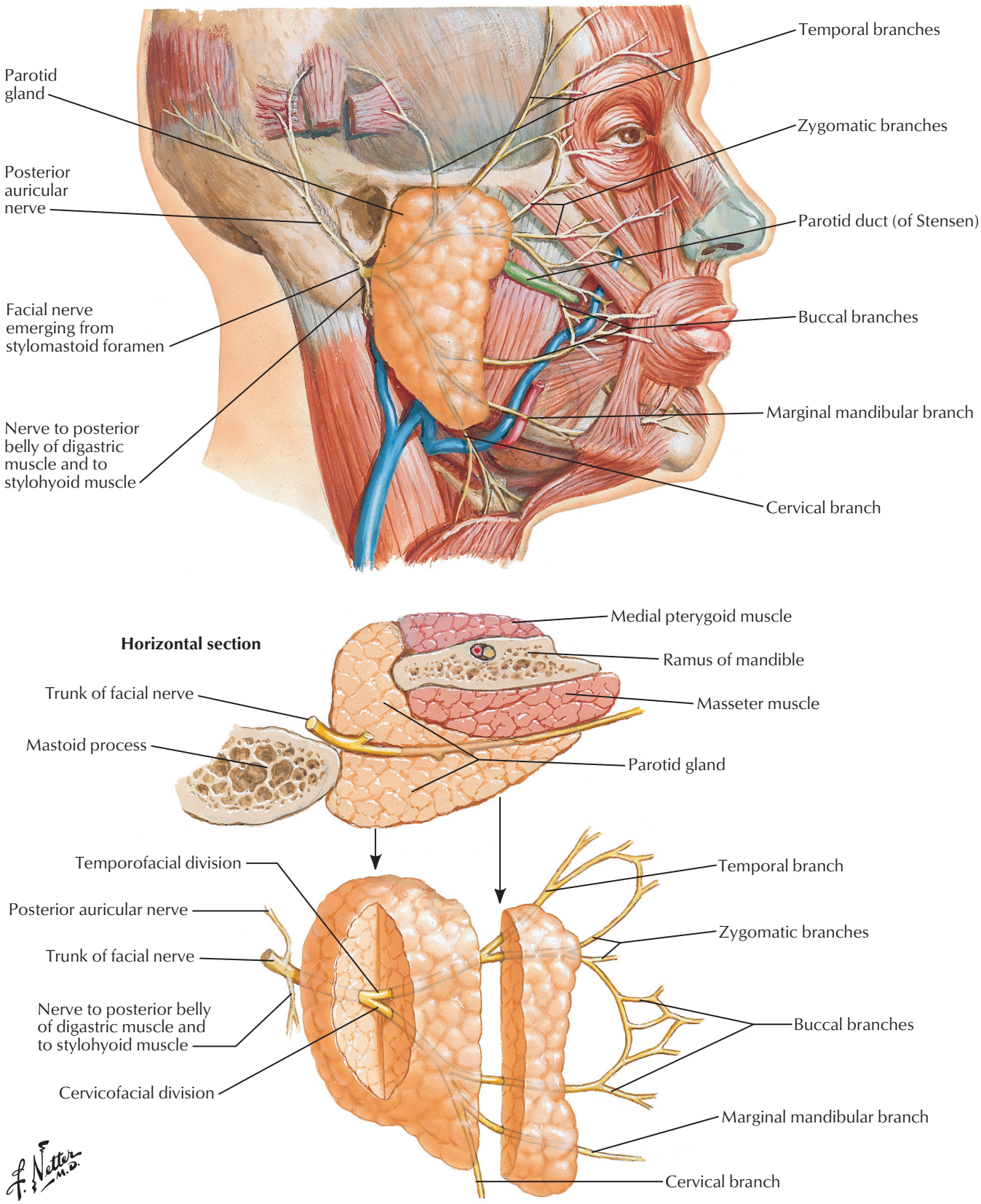
Cruciate ligament removed to show deeper ligaments: posterior view



Median atlanto-axial joint: superior view

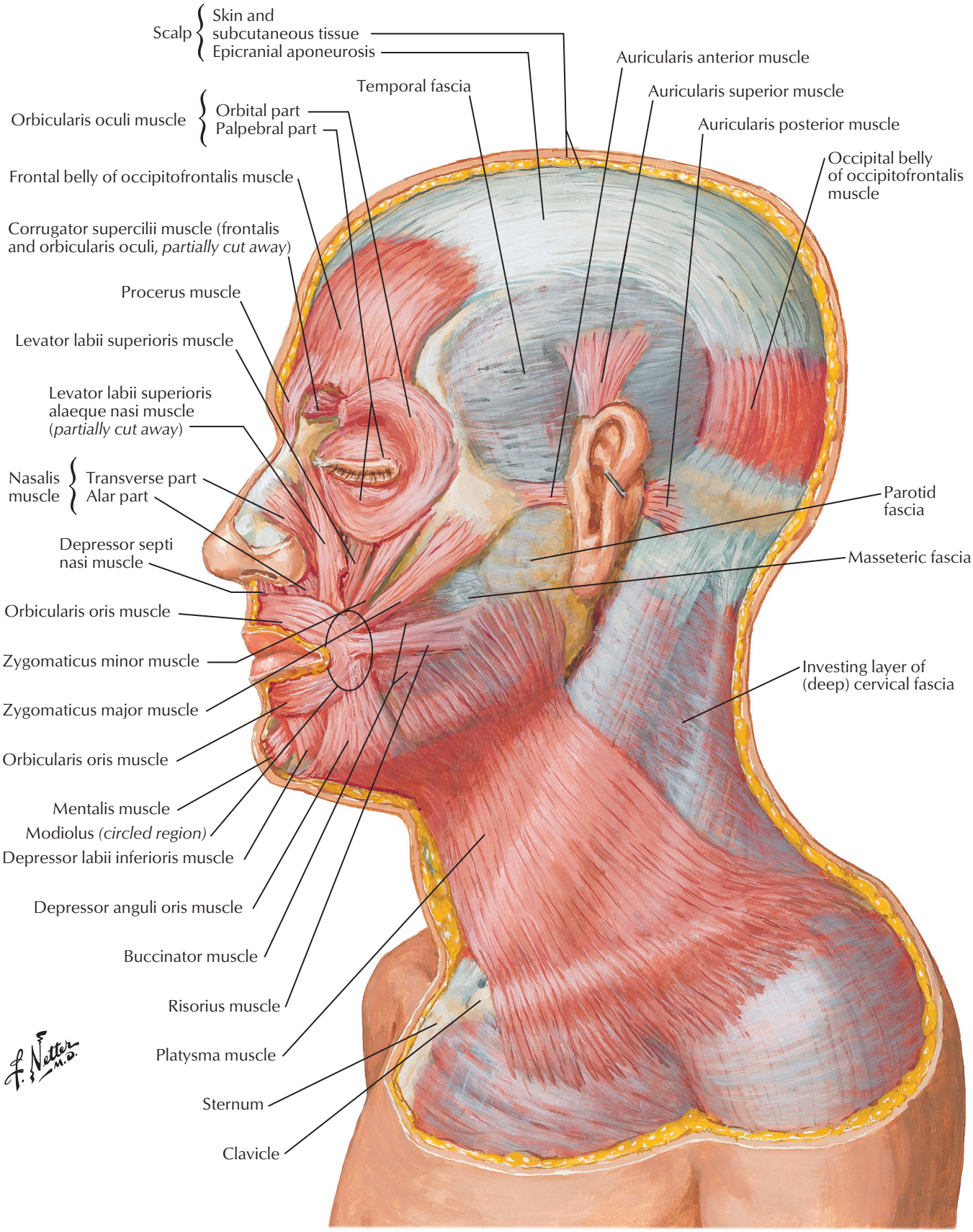
Facial Nerve Branches and Parotid Gland

See also Plates 46, 124



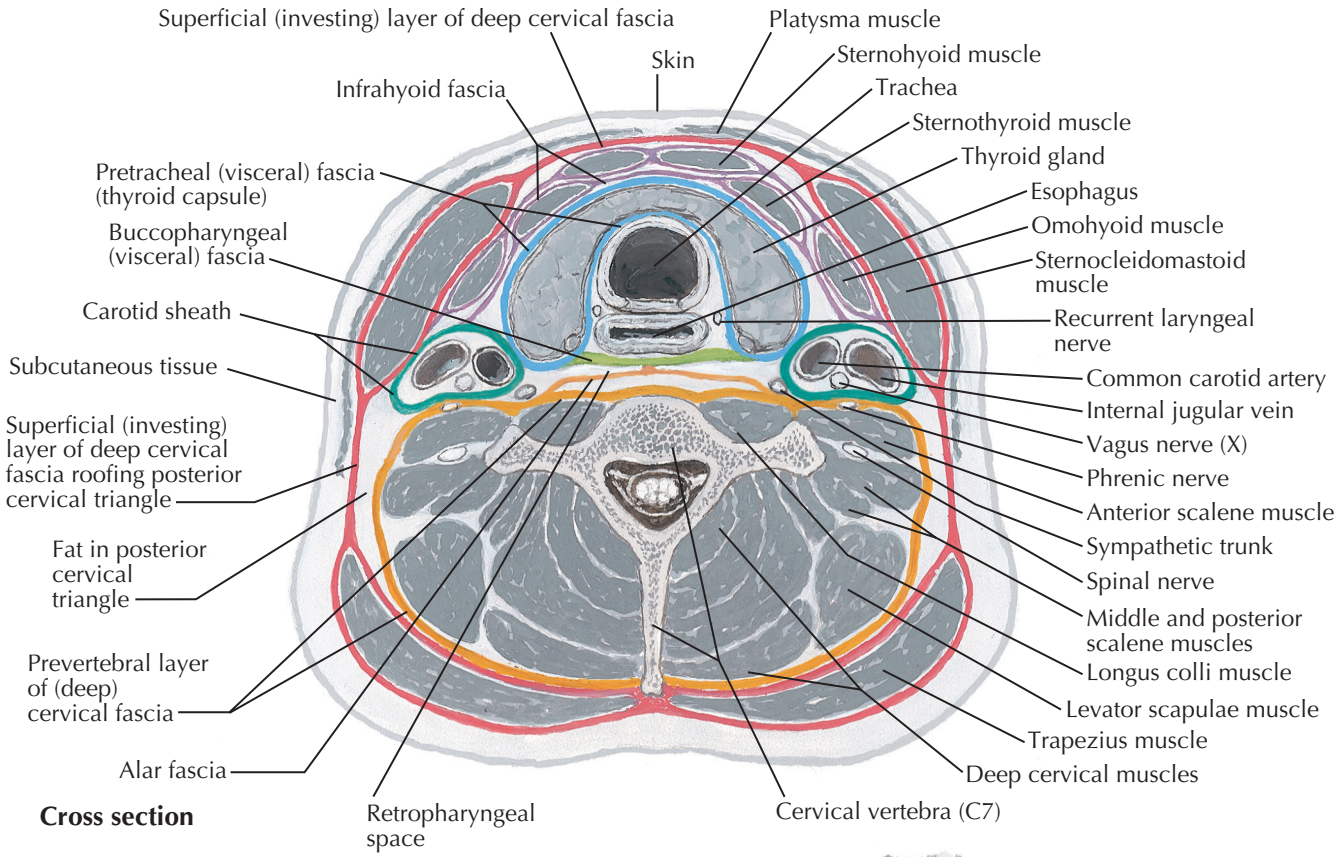
Muscles of Facial Expression: Lateral View

See also Plates 48, 49

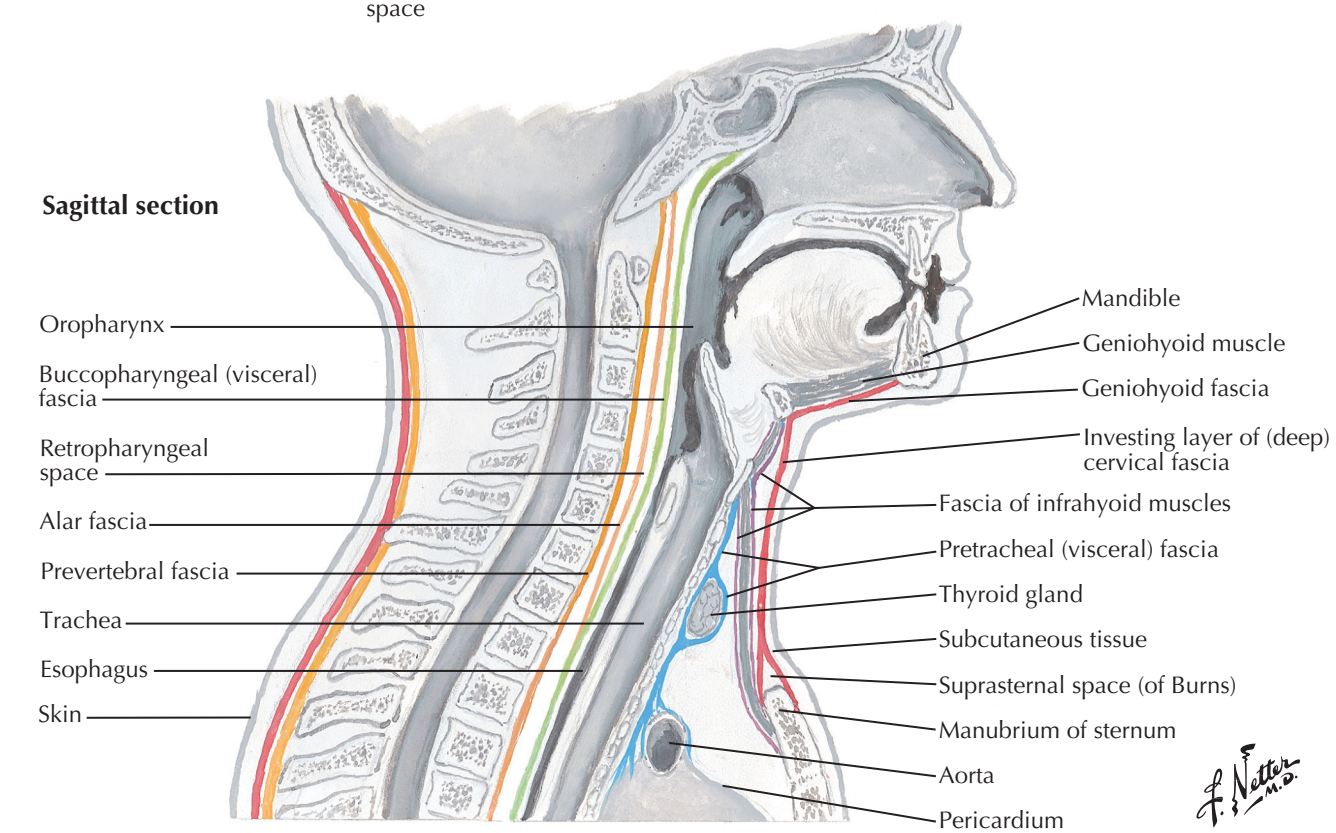


Fascial Layers of Neck

See also Plate 27



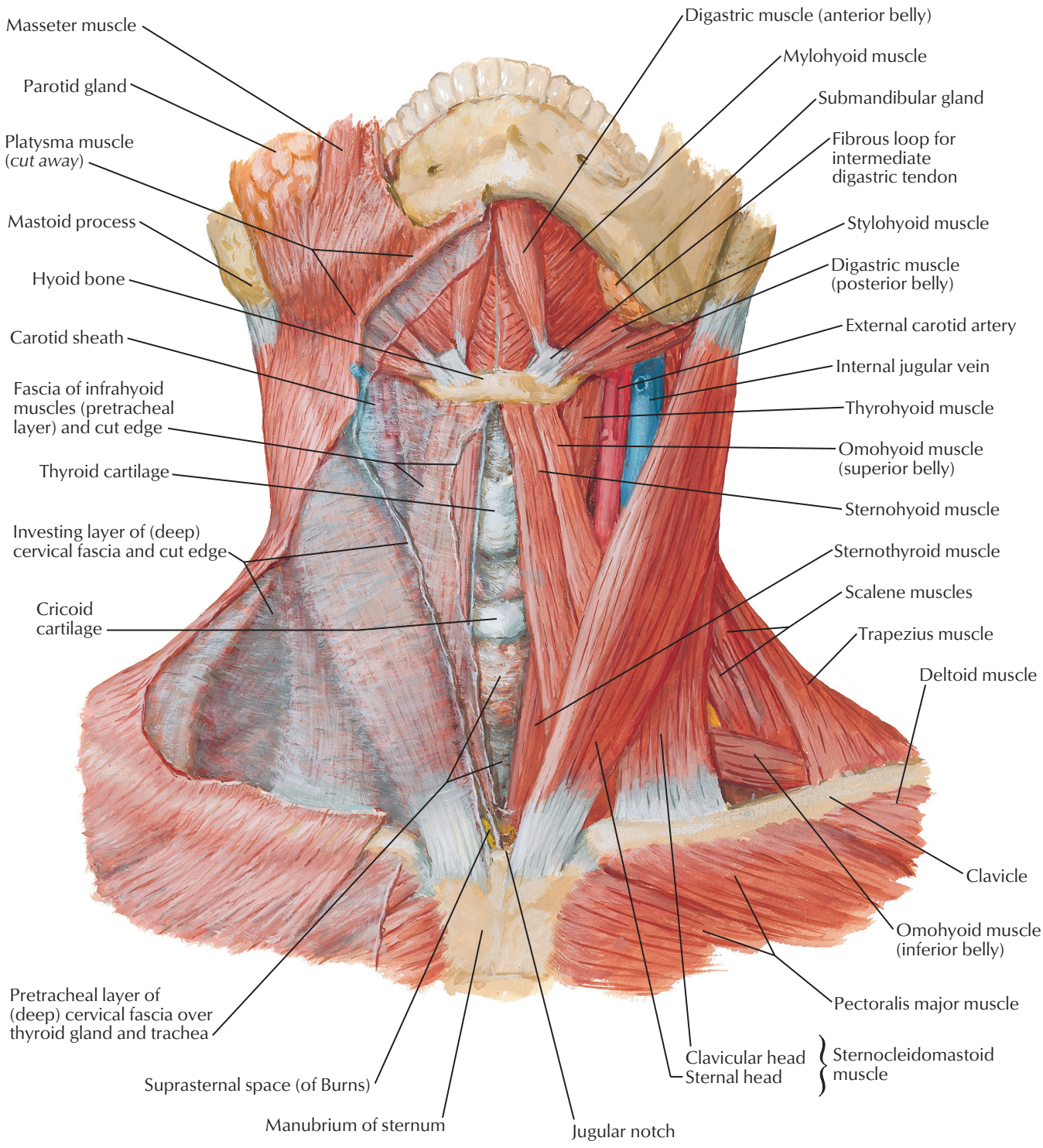
Cross section



Sagittal section

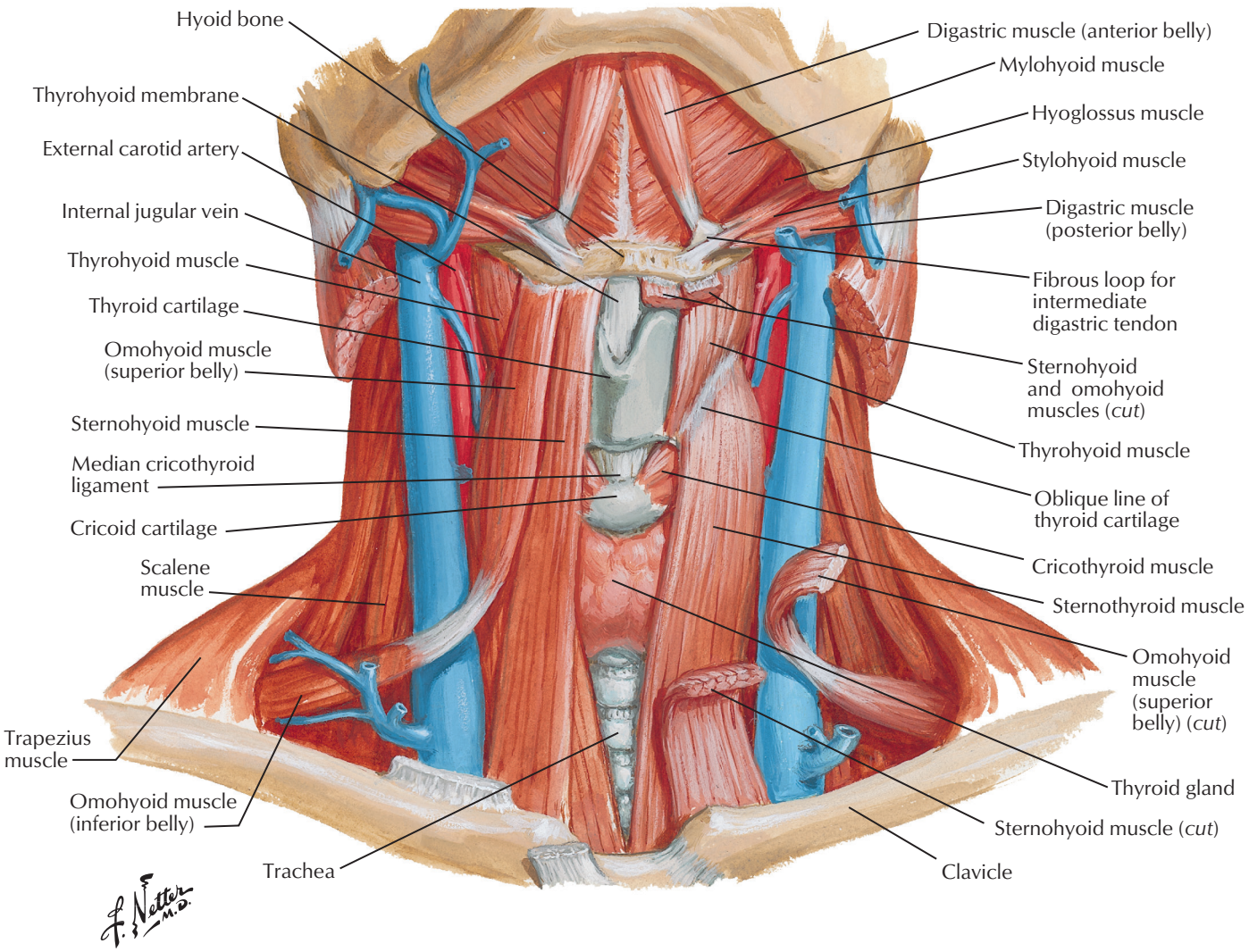
Muscles of Neck: Anterior View

See also Plates 26, 28, 31



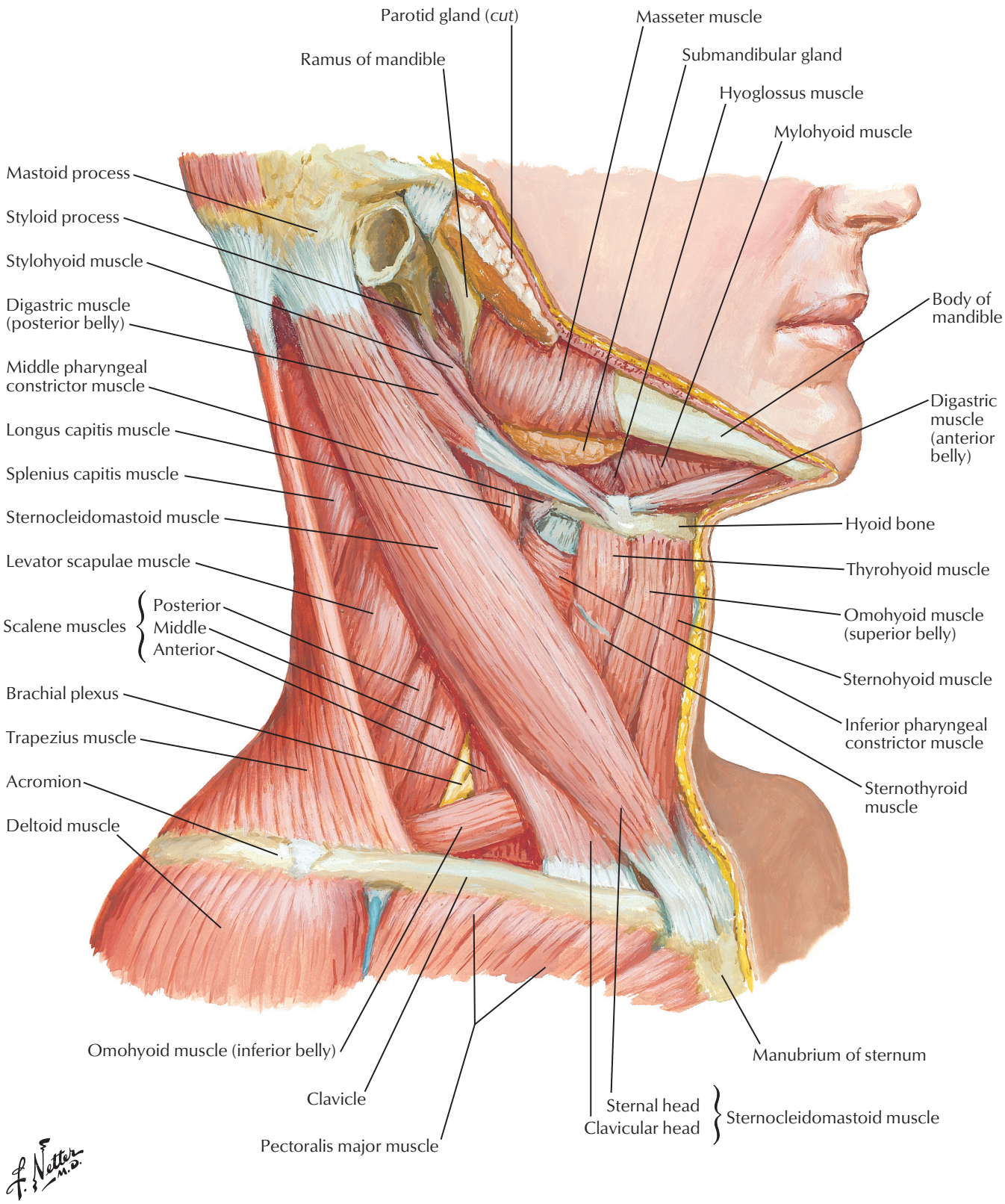
Infrahyoid and Suprahyoid Muscles

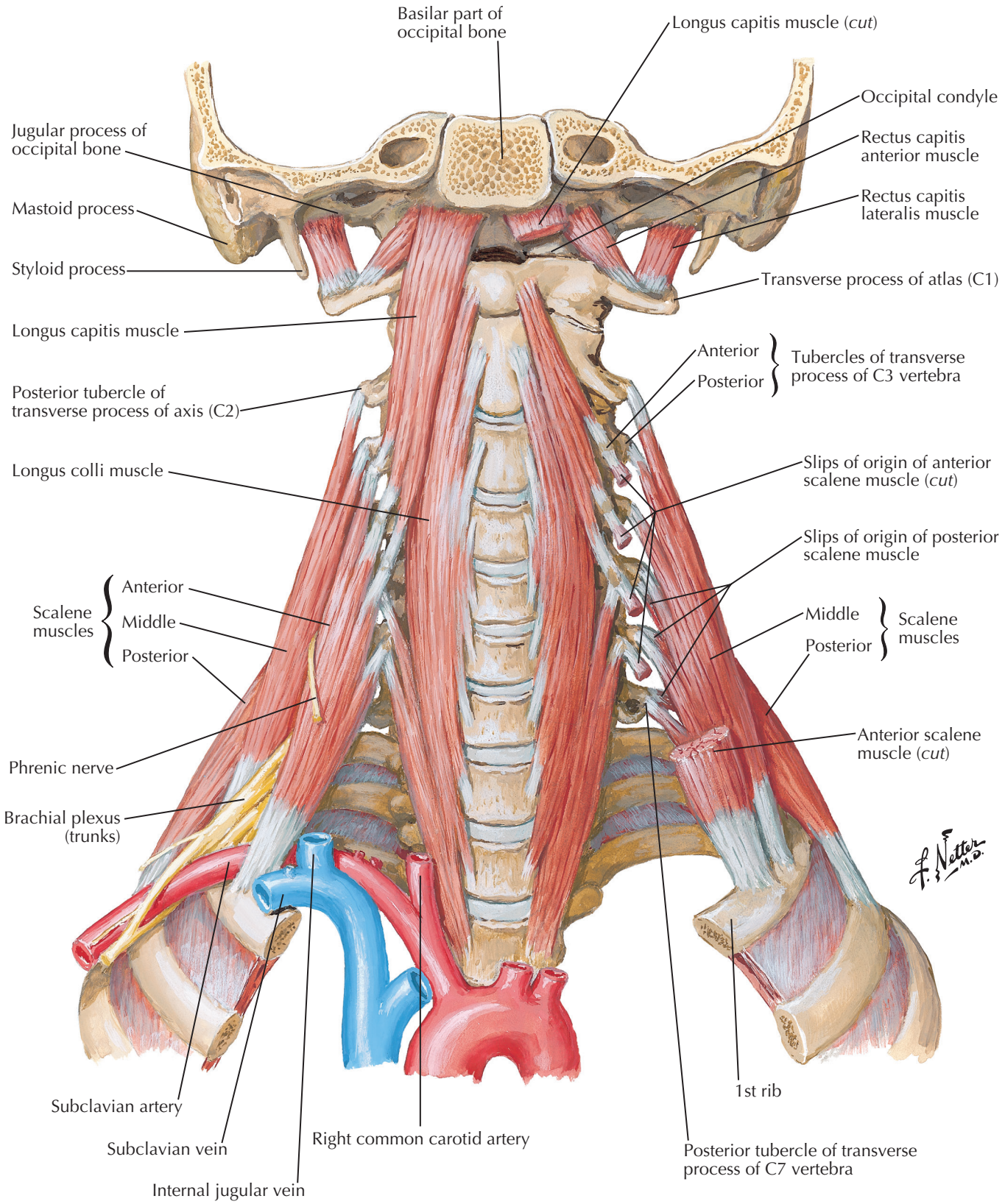
See also Plates 27, 29, 58



Muscles of Neck: Lateral View

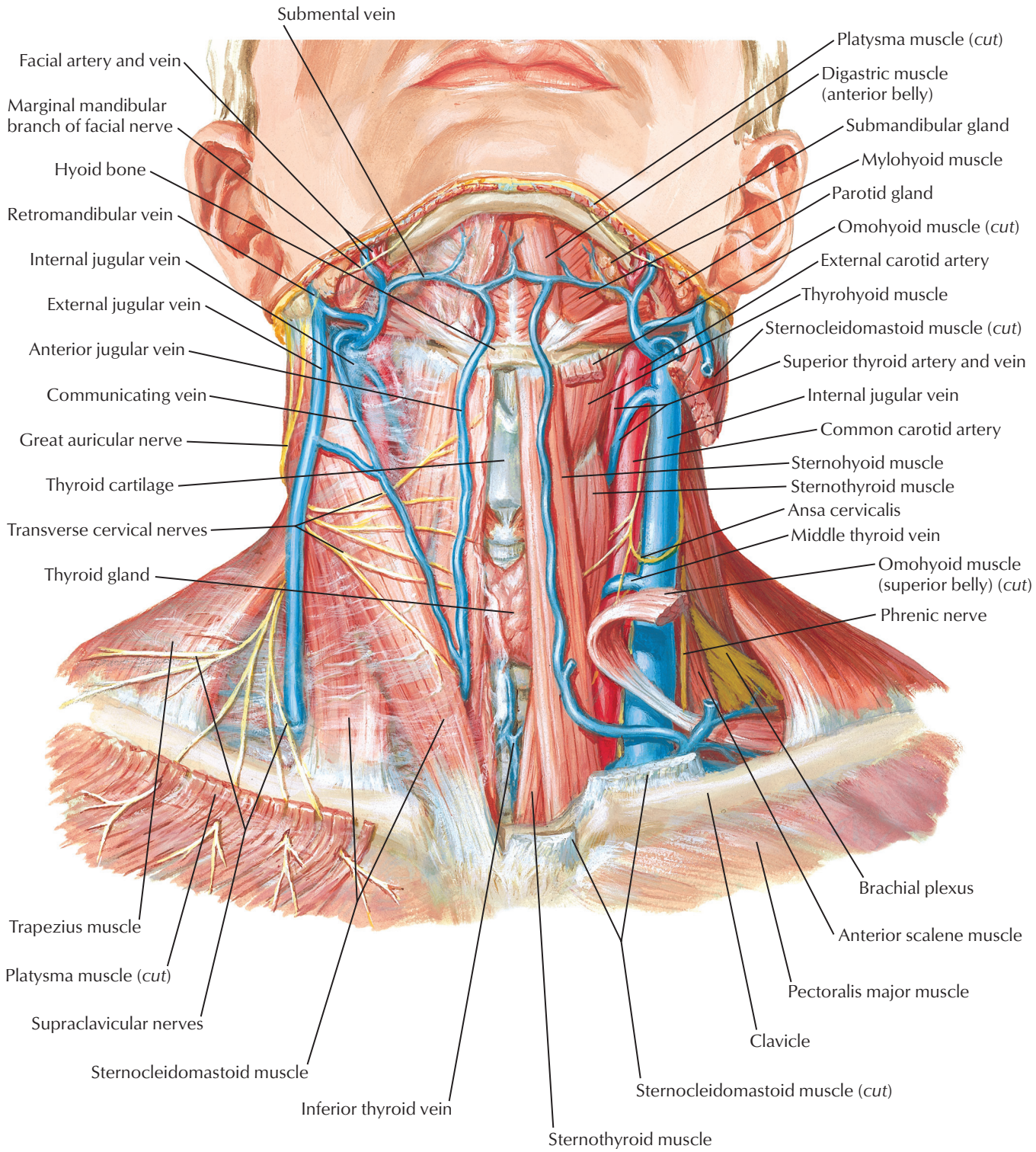
See also Plates 27, 28, 31



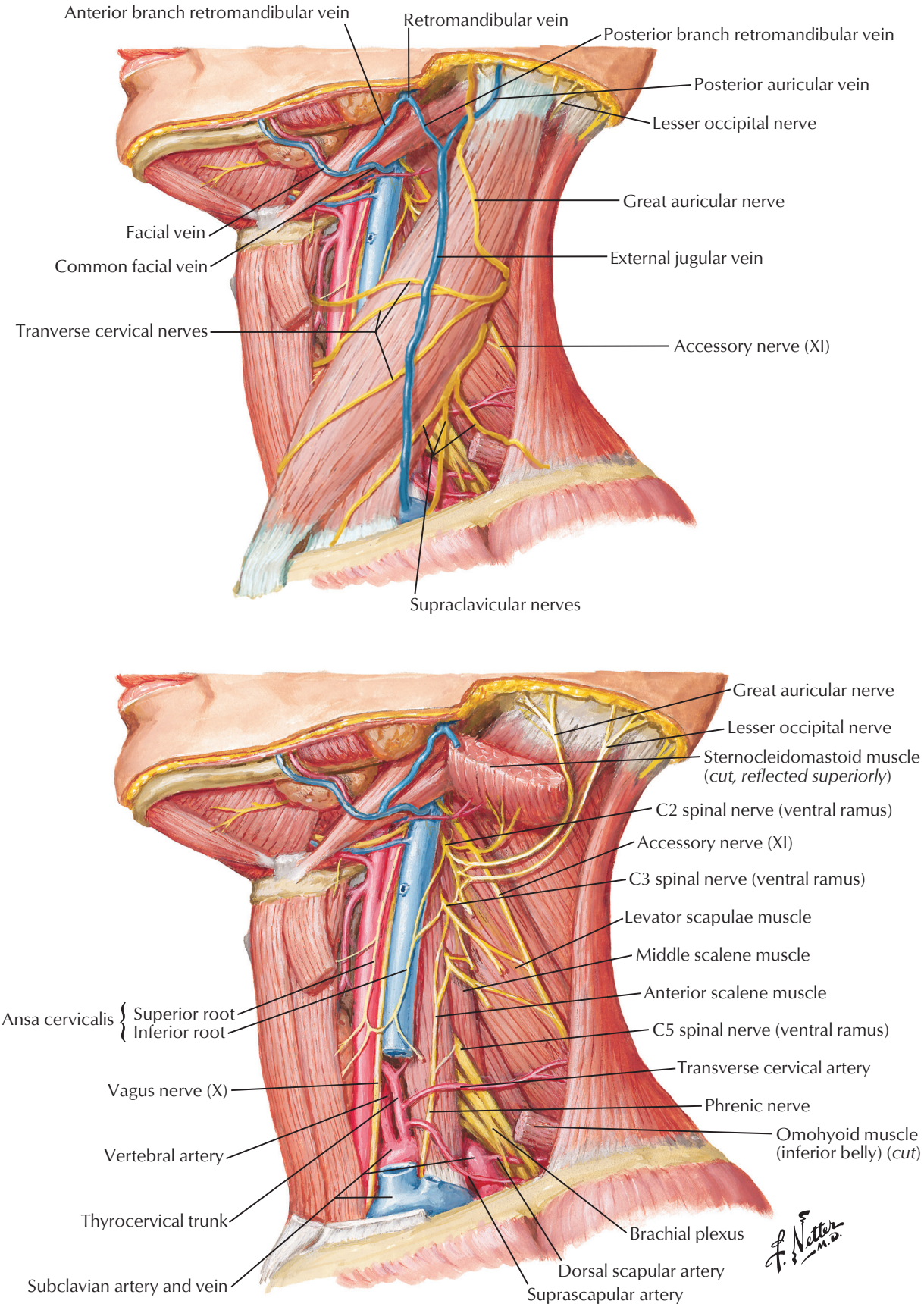

Basilar part of occipital bone
Longus capitis muscle (*cut*)
Occipital condyle
Jugular process of occipital bone
Rectus capitis anterior muscle
Mastoid process
Rectus capitis lateralis muscle
Styloid process
Transverse process of atlas (C1)
Longus capitis muscle
Anterior
Posterior
Tubercles of transverse process of C3 vertebra
Posterior tubercle of transverse process of axis (C2)
Longus colli muscle
Slips of origin of anterior scalene muscle (*cut*)
Slips of origin of posterior scalene muscle
Scalene muscles
Anterior
Middle
Posterior
Middle
Posterior
Scalene muscles
Anterior scalene muscle (*cut*)
Phrenic nerve
Brachial plexus (trunks)
1st rib
Subclavian artery
Subclavian vein
Right common carotid artery
Internal jugular vein
Posterior tubercle of transverse process of C7 vertebra

Superficial Veins and Cutaneous Nerves of Neck

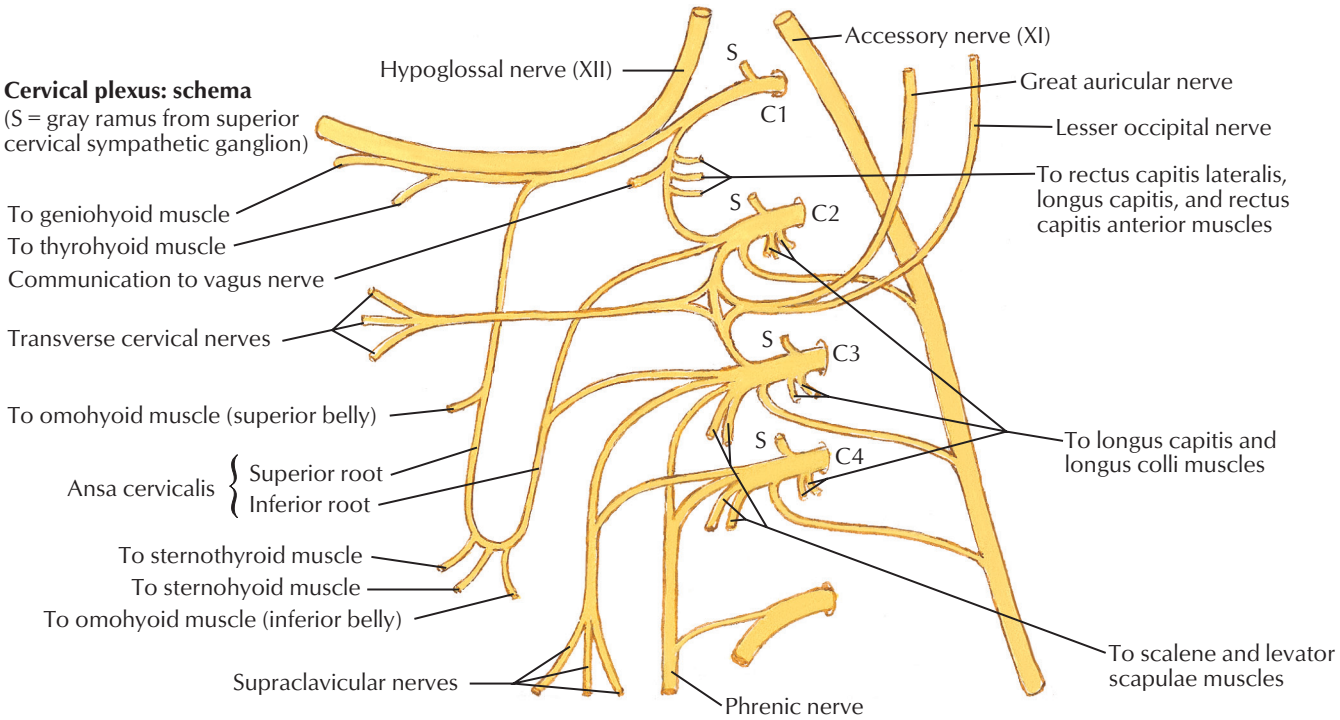
For deep veins of neck see Plate 73



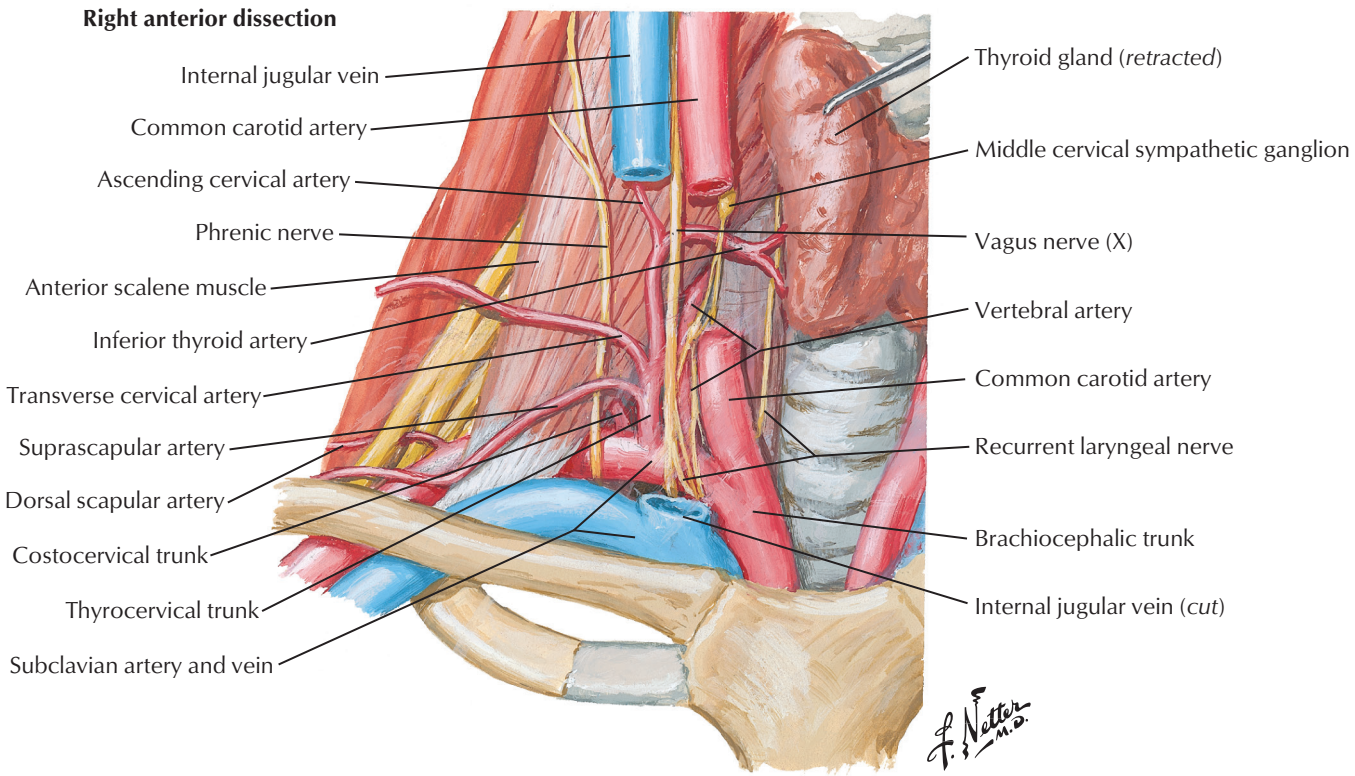
See also Plates 128–130



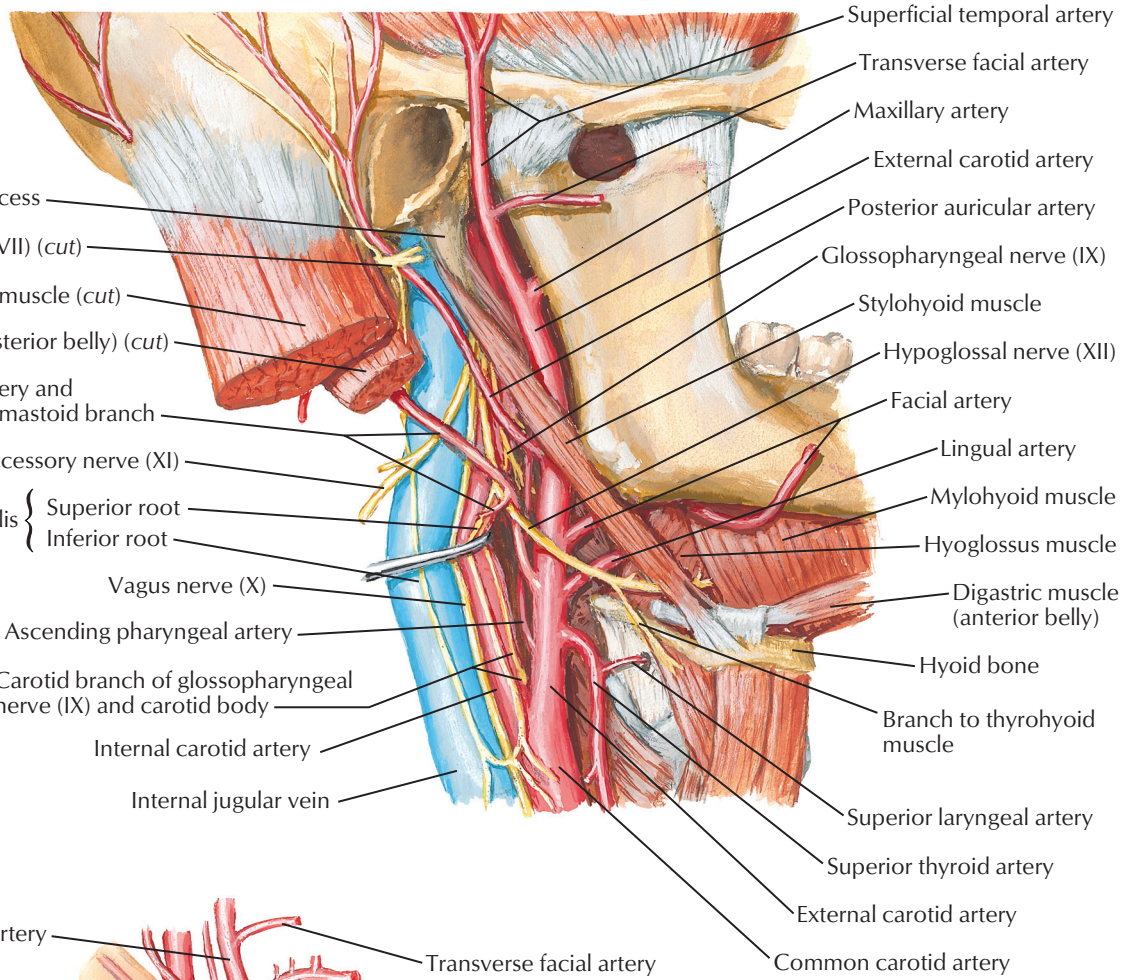
Cervical plexus: schema
(S = gray ramus from superior cervical sympathetic ganglion)

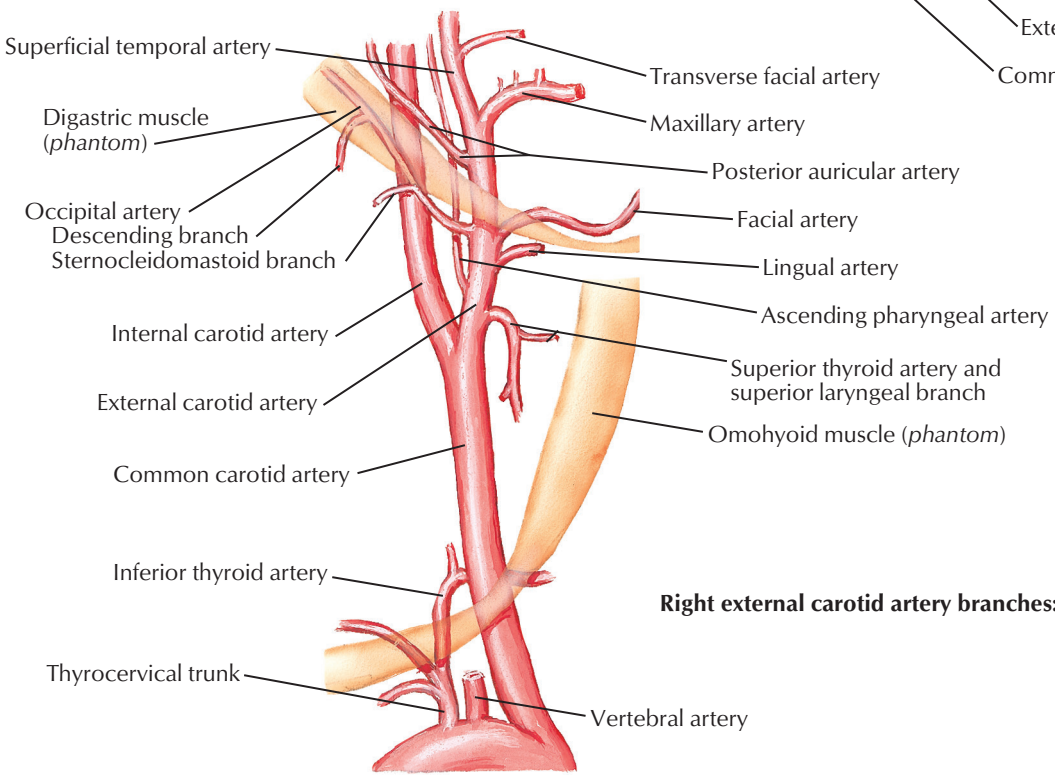


Right anterior dissection



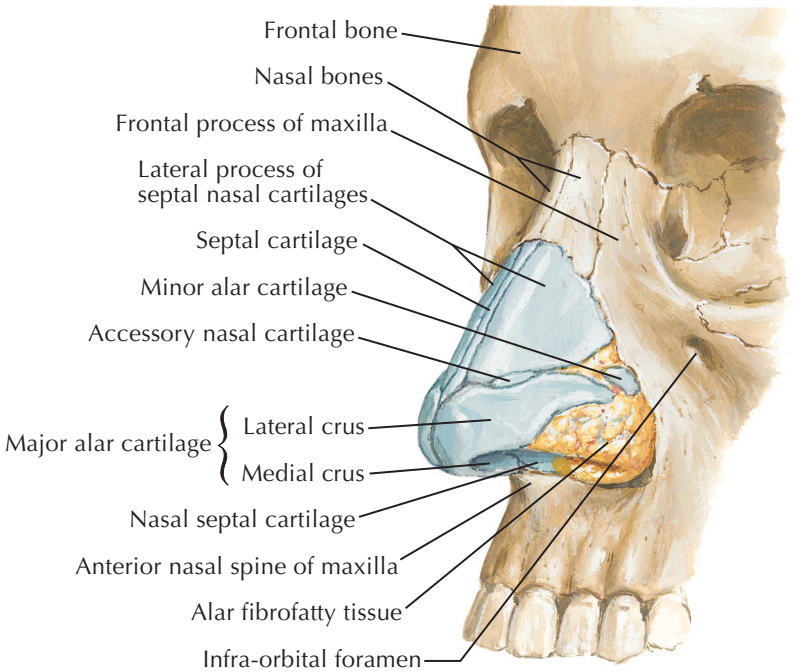
Parotid space (bed): right lateral dissection



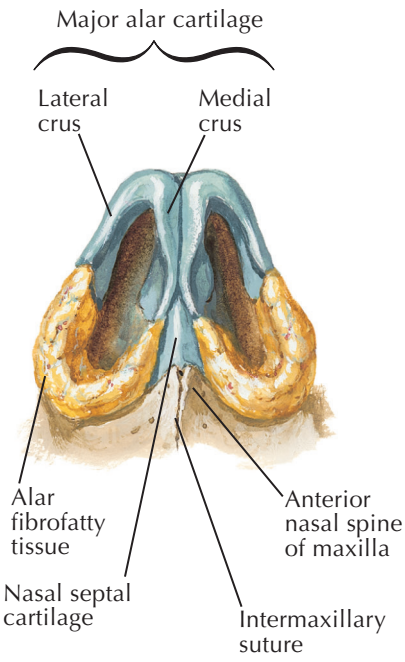


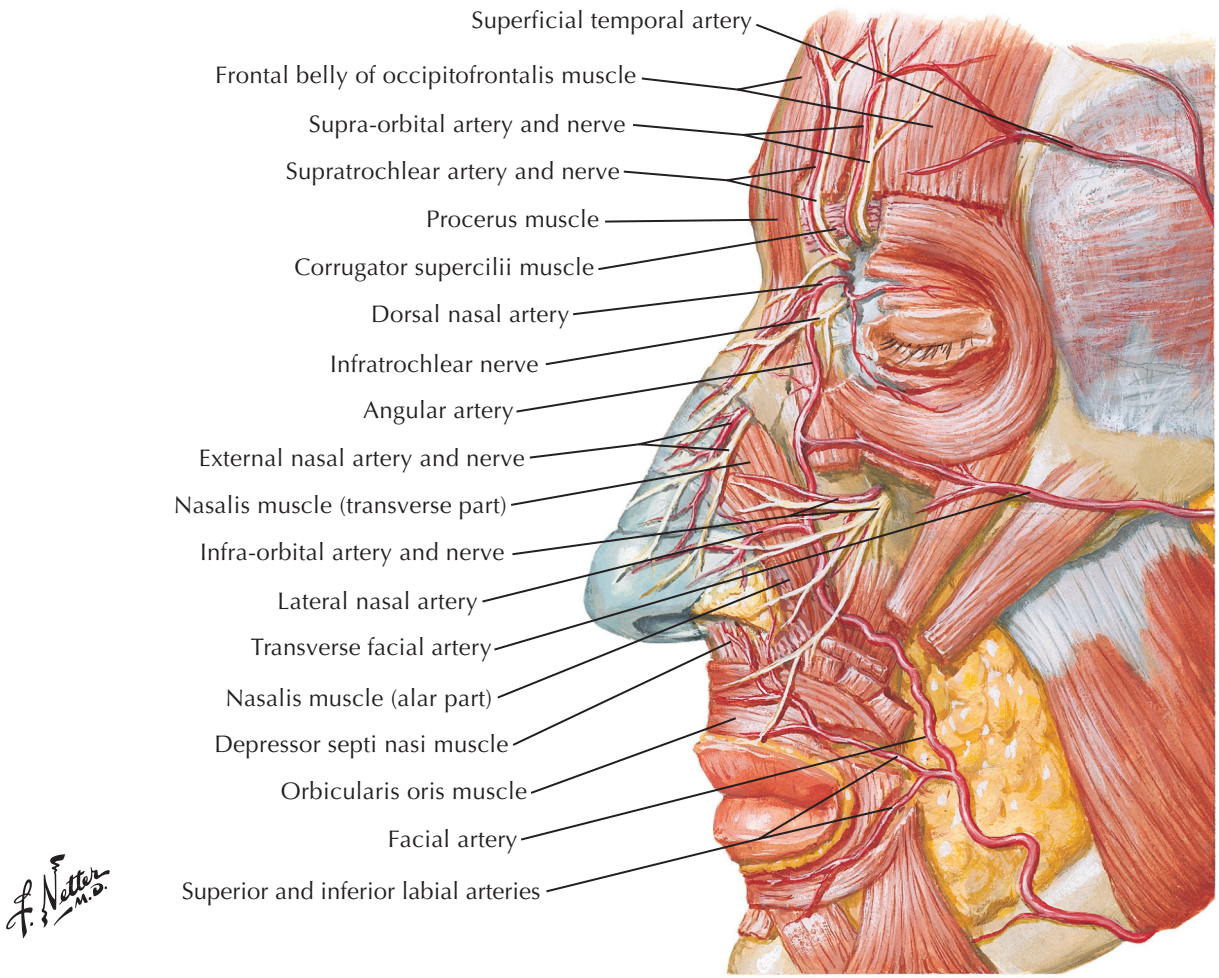
Right external carotid artery branches: schema

Anterolateral view

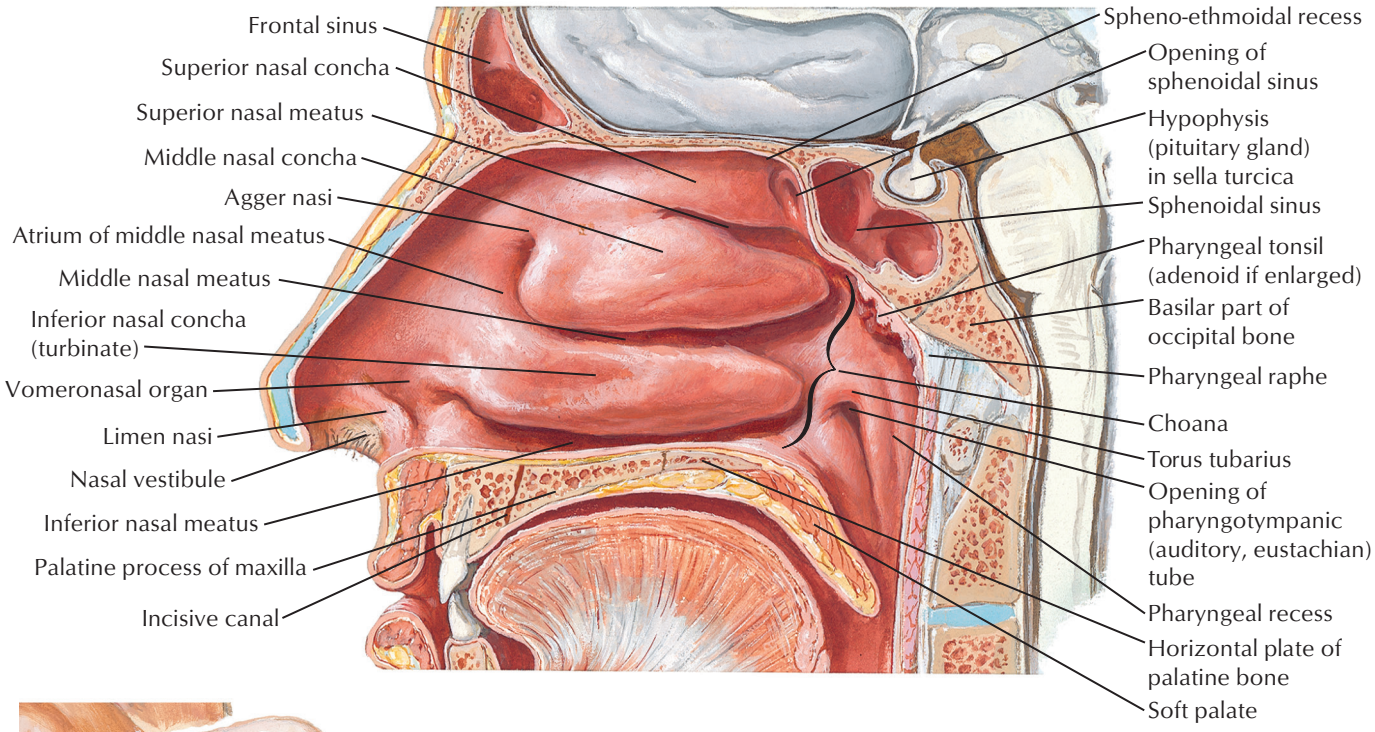


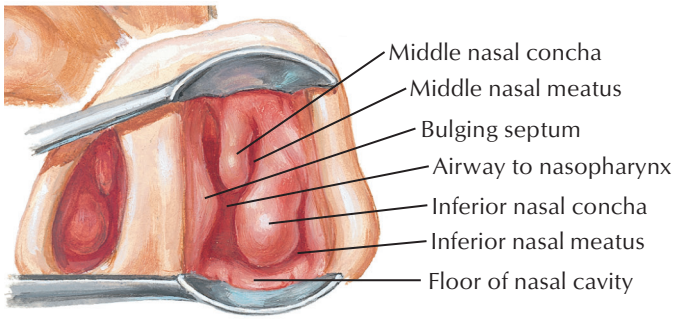
Inferior view



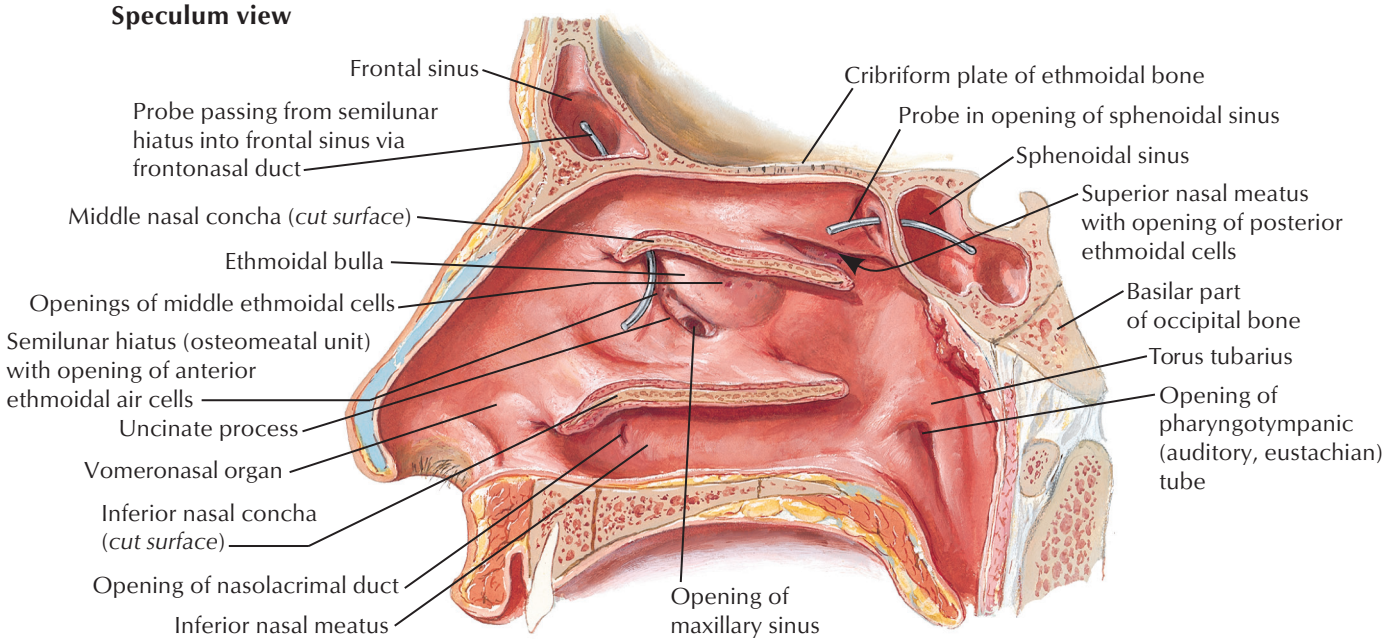


Lateral Wall of Nasal Cavity



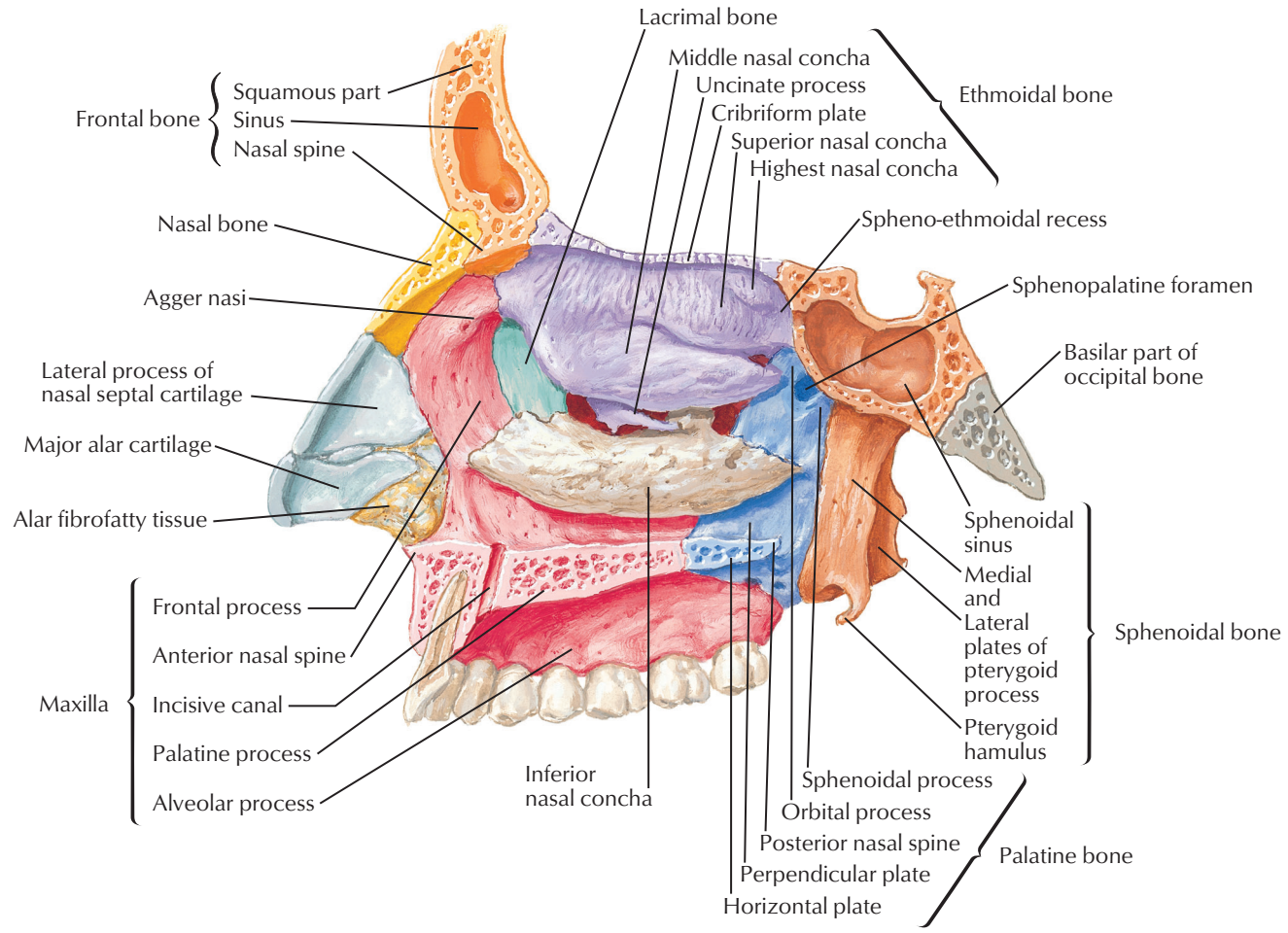


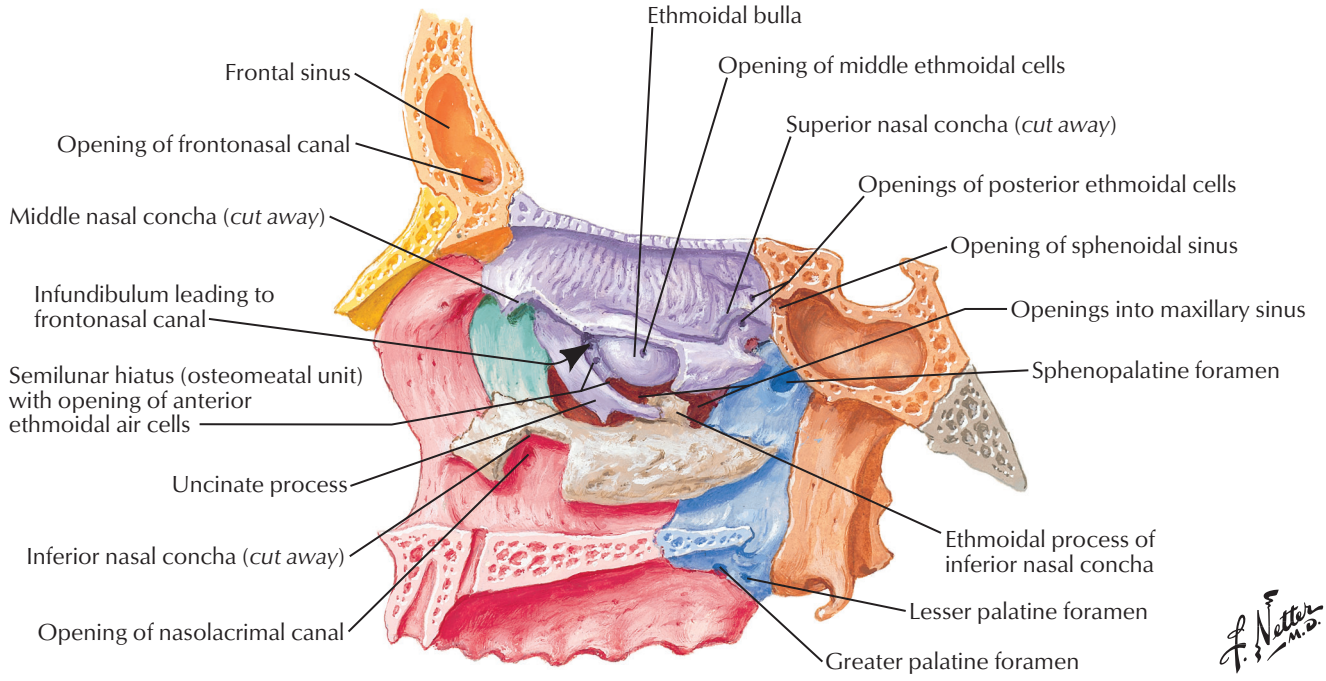
Speculum view



Lateral Wall of Nasal Cavity (continued)

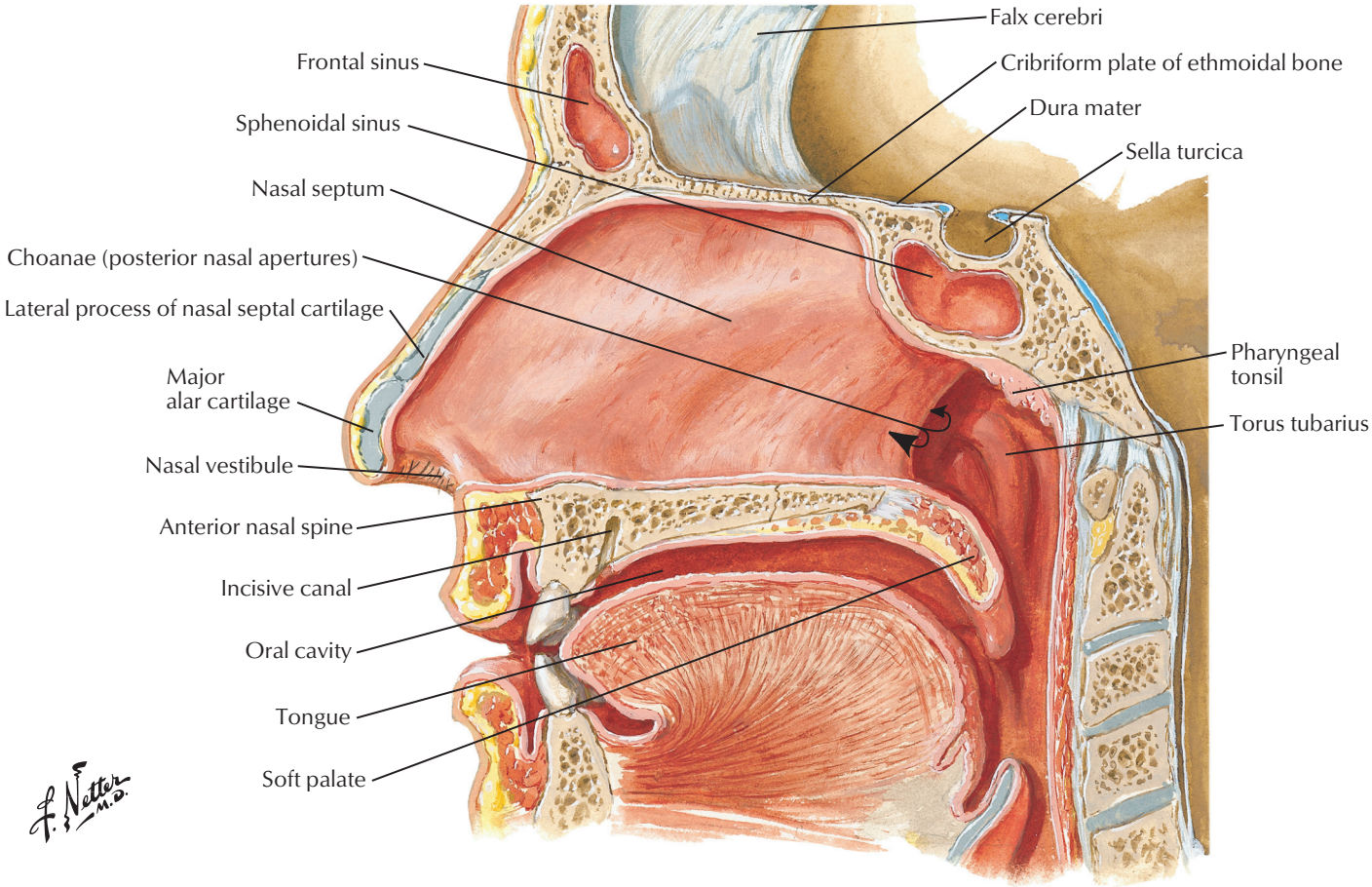
See also Plate 36

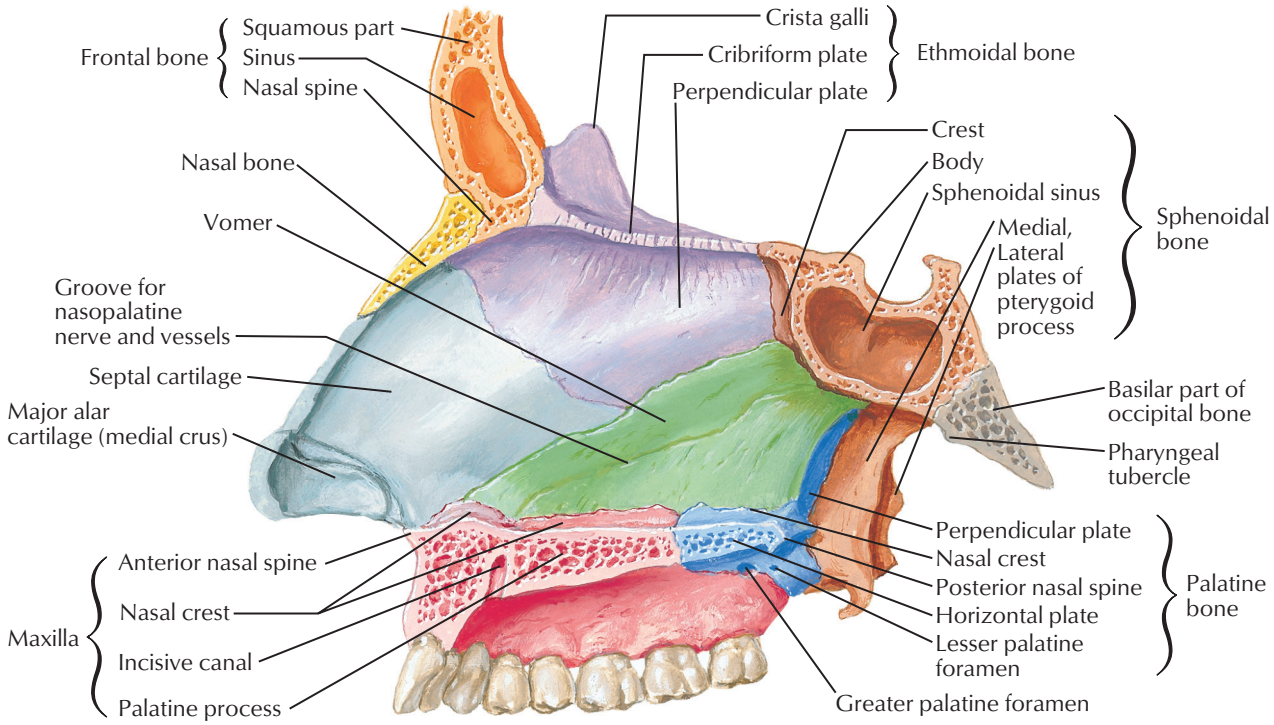




Medial Wall of Nasal Cavity (Nasal Septum)

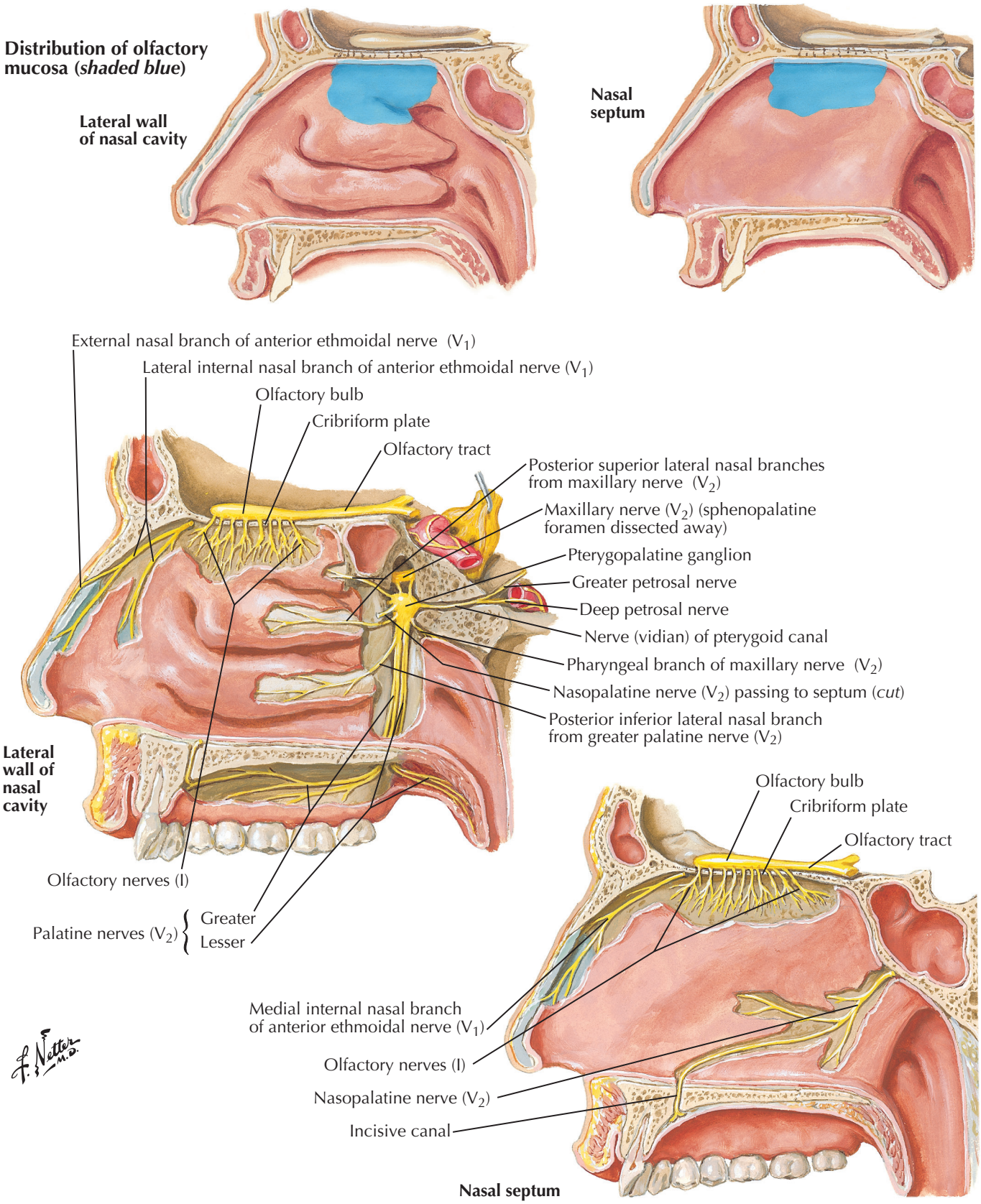
See also Plate 8





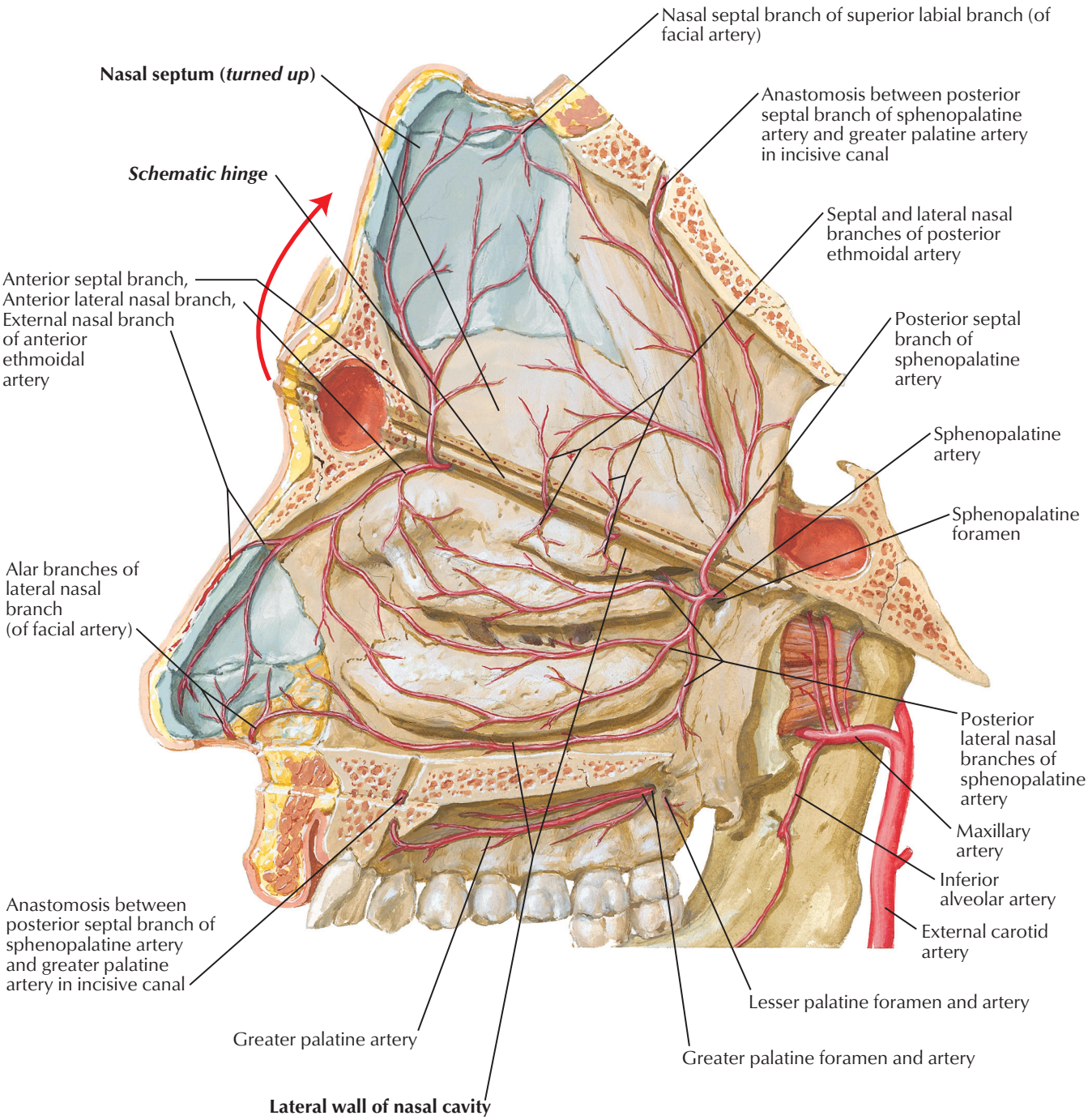
Nerves of Nasal Cavity

See also Plates 54, 62, 120



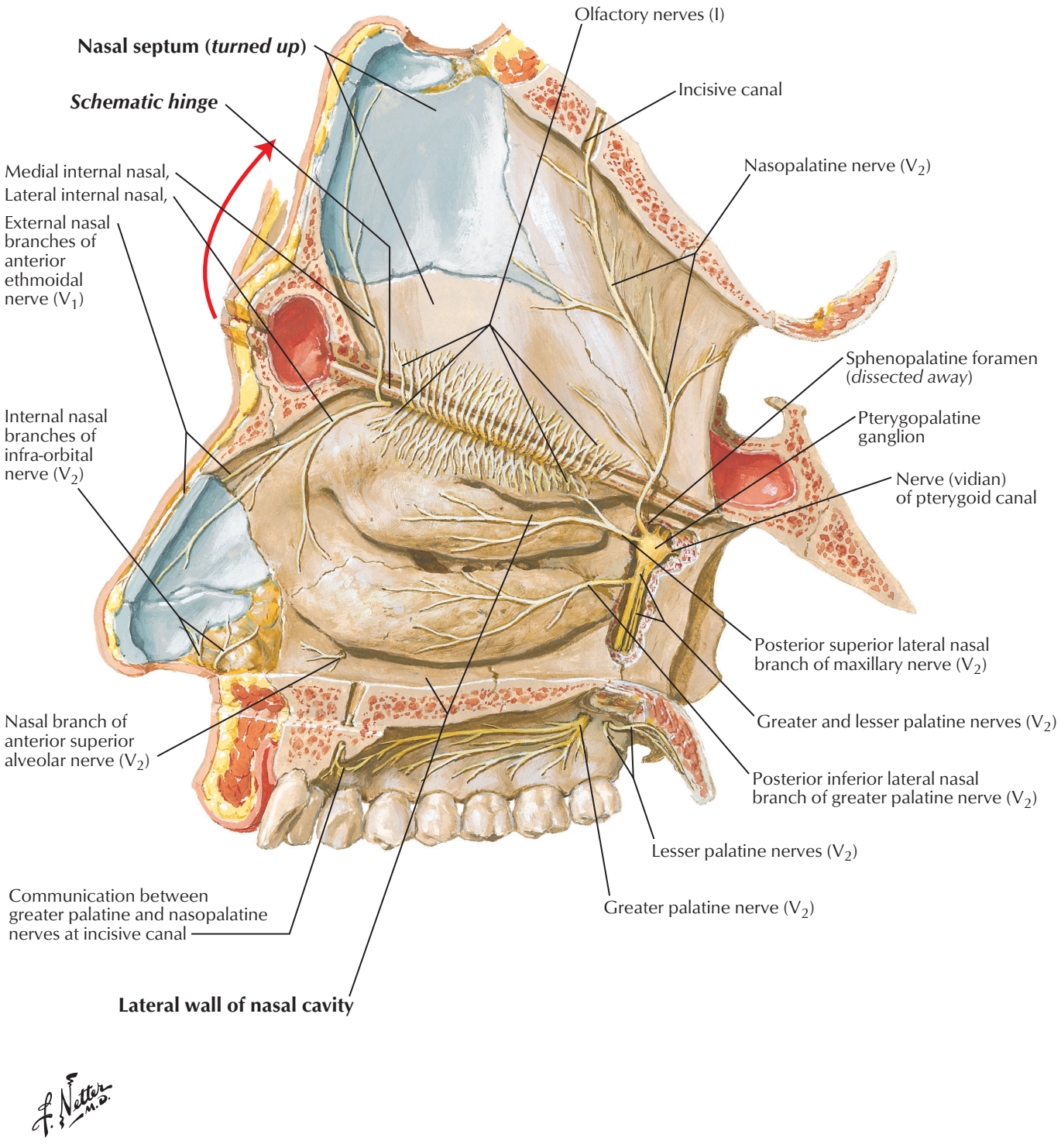
Arteries of Nasal Cavity: Nasal Septum Turned Up

See also Plate 57

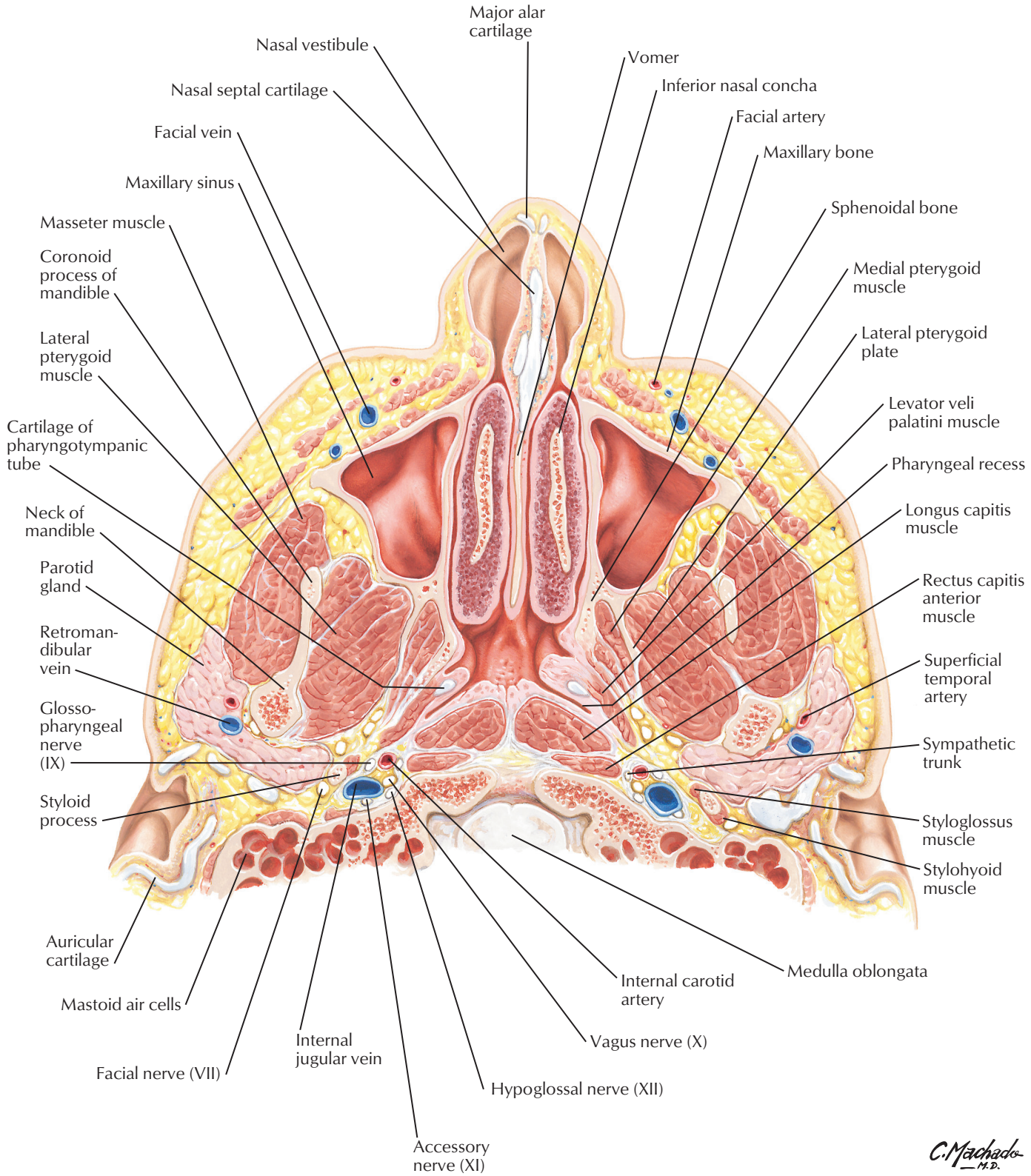


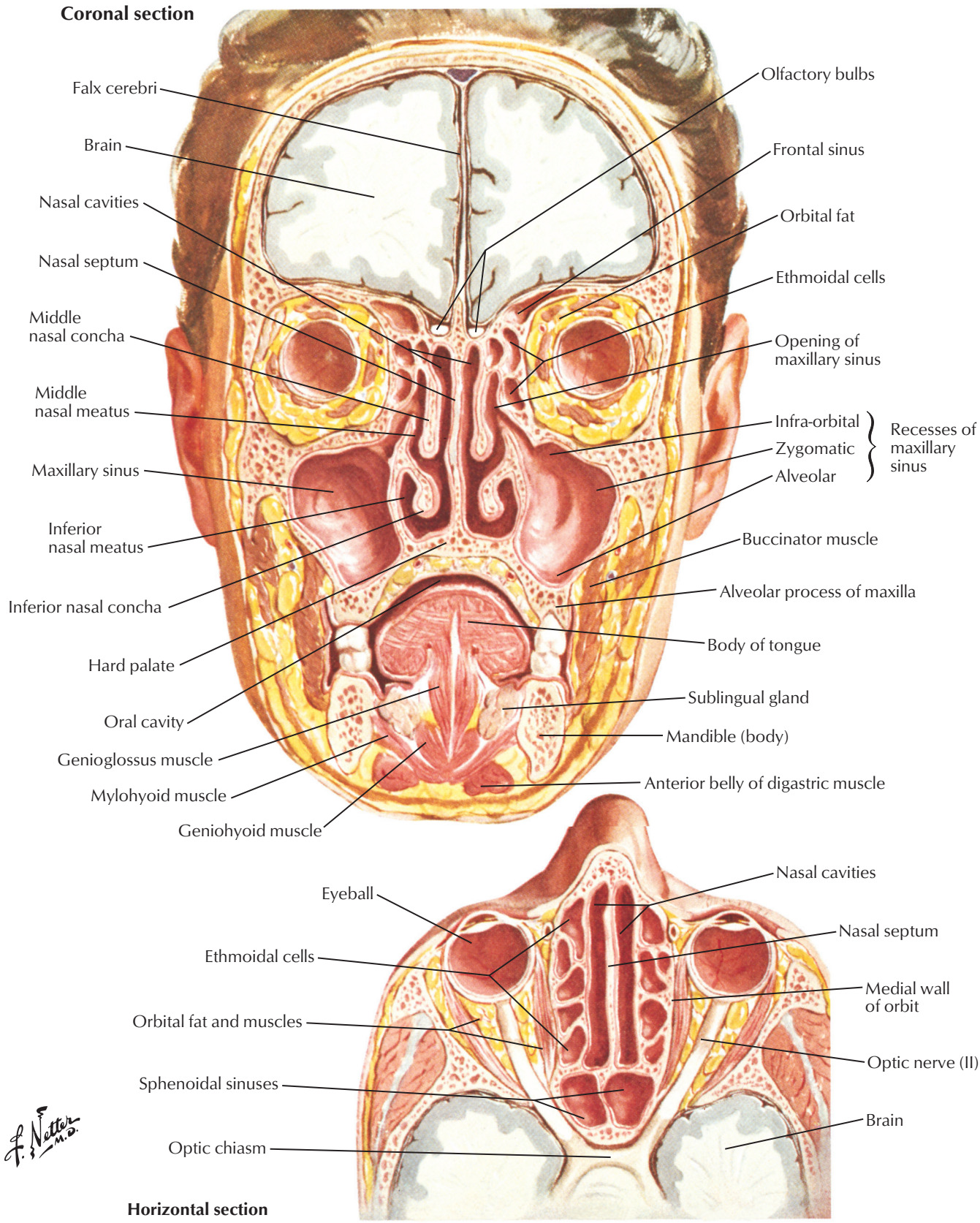
Nerves of Nasal Cavity: Nasal Septum Turned Up

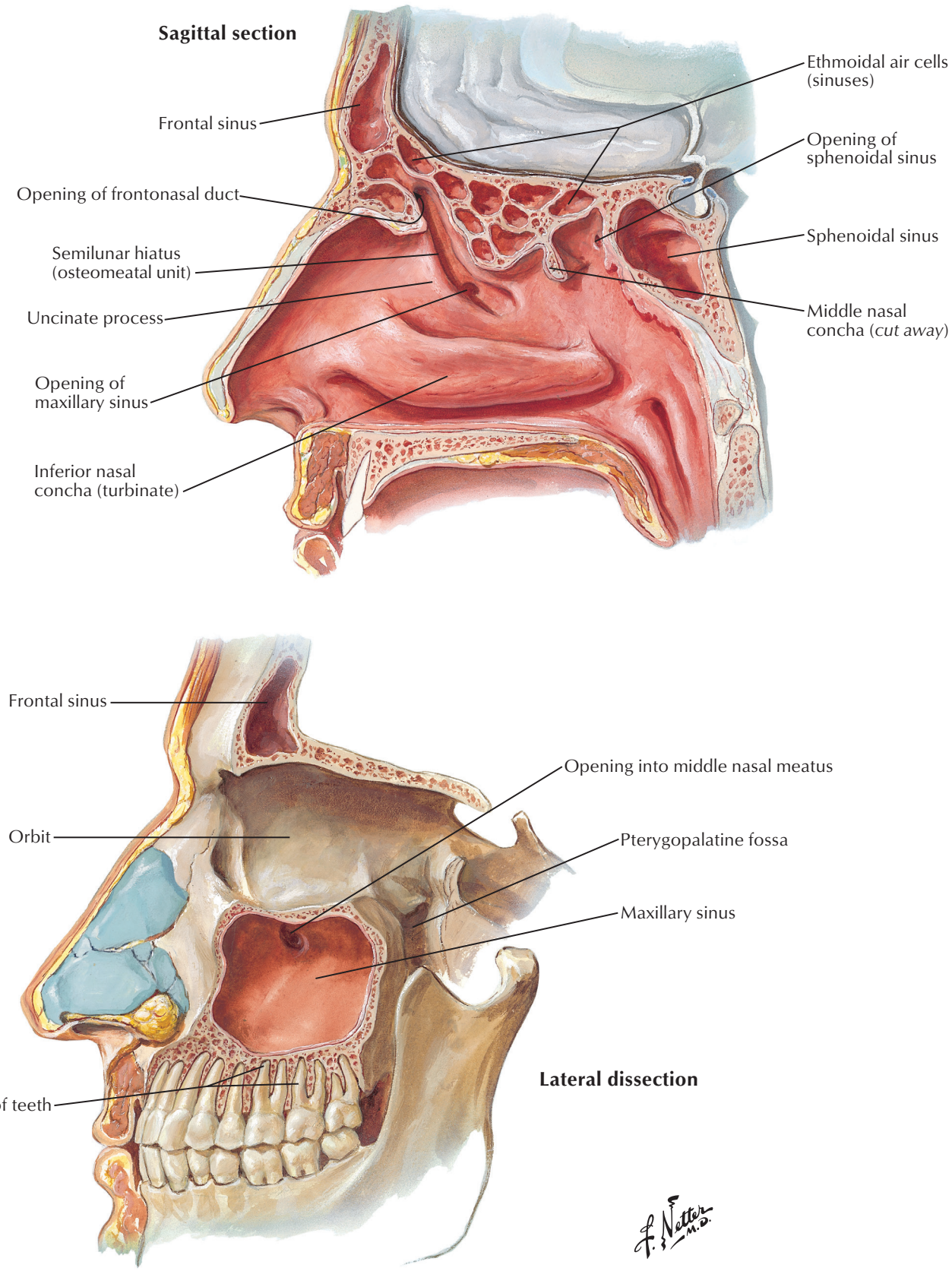
See also Plates 52, 53



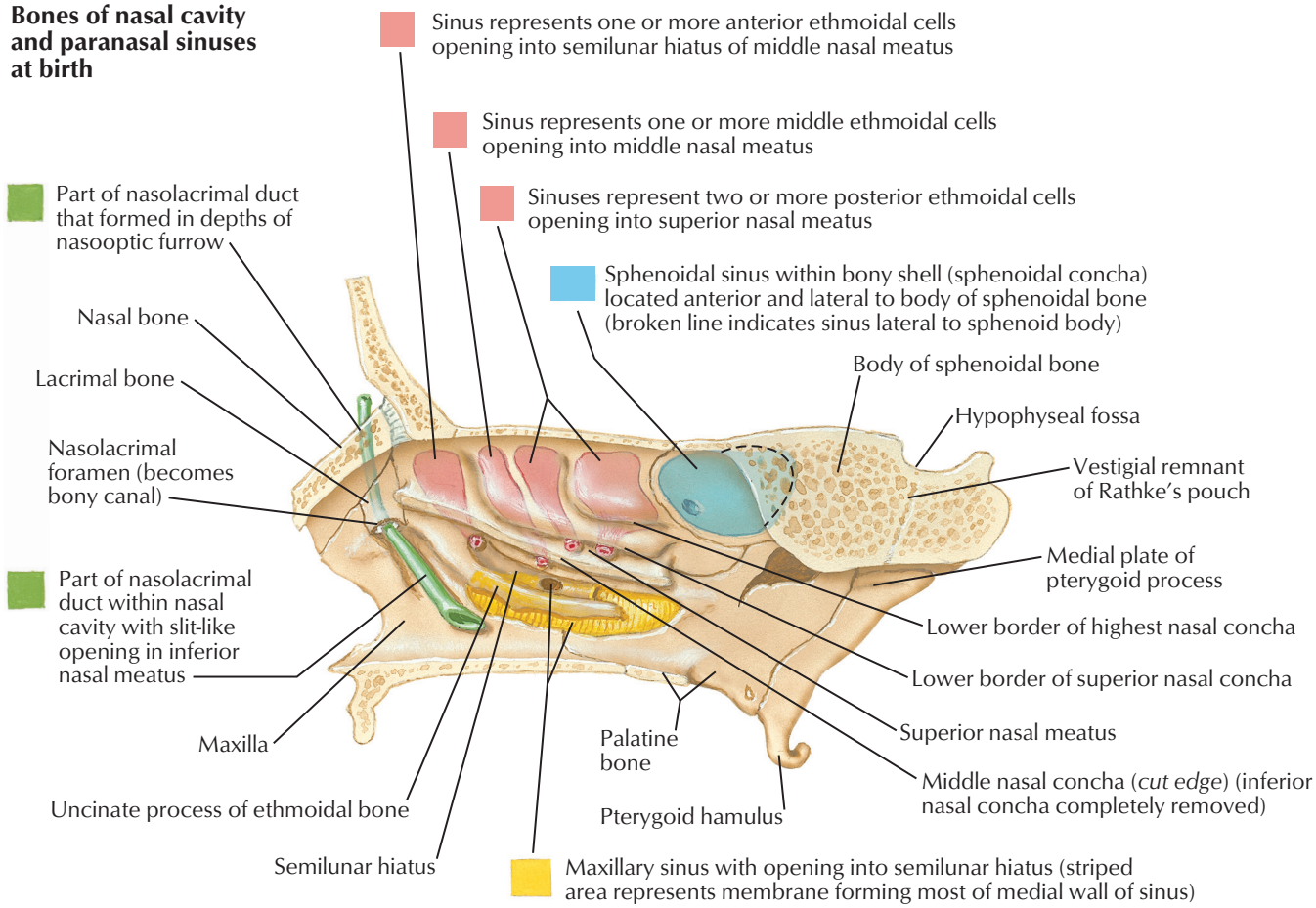
Nose and Maxillary Sinus: Transverse Section



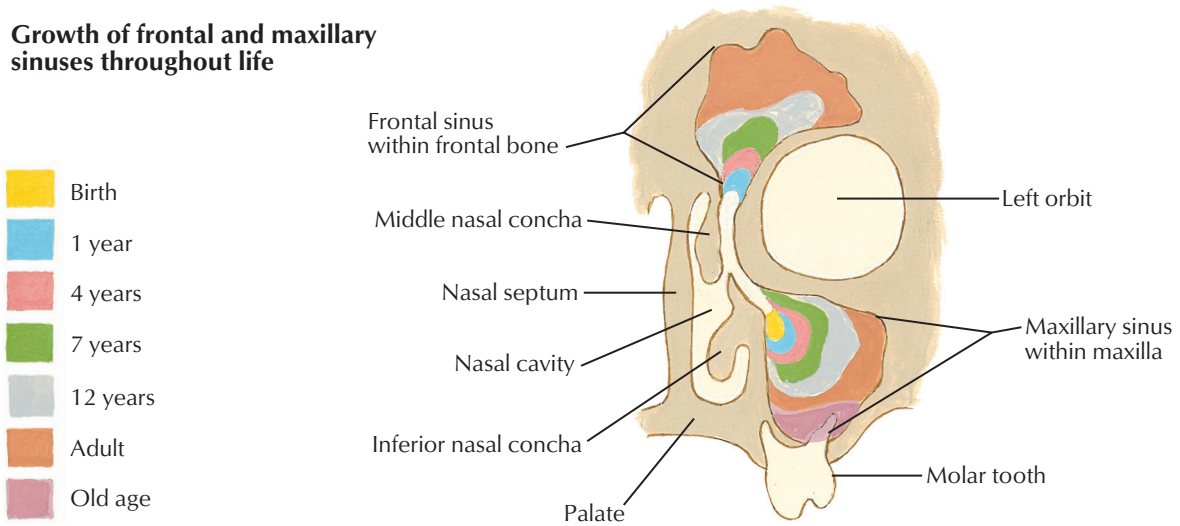

Coronal section
Falx cerebri
Brain
Nasal cavities
Nasal septum
Middle nasal concha
Middle nasal meatus
Maxillary sinus
Inferior nasal meatus
Inferior nasal concha
Hard palate
Oral cavity
Genioglossus muscle
Mylohyoid muscle
Geniohyoid muscle
Olfactory bulbs
Frontal sinus
Orbital fat
Ethmoidal cells
Opening of maxillary sinus
Infra-orbital
Zygomatic
Alveolar
Recesses of maxillary sinus
Buccinator muscle
Alveolar process of maxilla
Body of tongue
Sublingual gland
Mandible (body)
Anterior belly of digastric muscle
Eyeball
Ethmoidal cells
Orbital fat and muscles
Sphenoidal sinuses
Optic chiasm
Nasal cavities
Nasal septum
Medial wall of orbit
Optic nerve (II)
Brain
Horizontal section


Sagittal section
Ethmoidal air cells (sinuses)
Frontal sinus
Opening of sphenoidal sinus
Opening of frontonasal duct
Sphenoidal sinus
Semilunar hiatus (osteomeatal unit)
Middle nasal concha (cut away)
Uncinate process
Opening of maxillary sinus
Inferior nasal concha (turbinate)
Frontal sinus
Opening into middle nasal meatus
Orbit
Pterygopalatine fossa
Maxillary sinus
Roots of teeth
Lateral dissection

Bones of nasal cavity and paranasal sinuses at birth



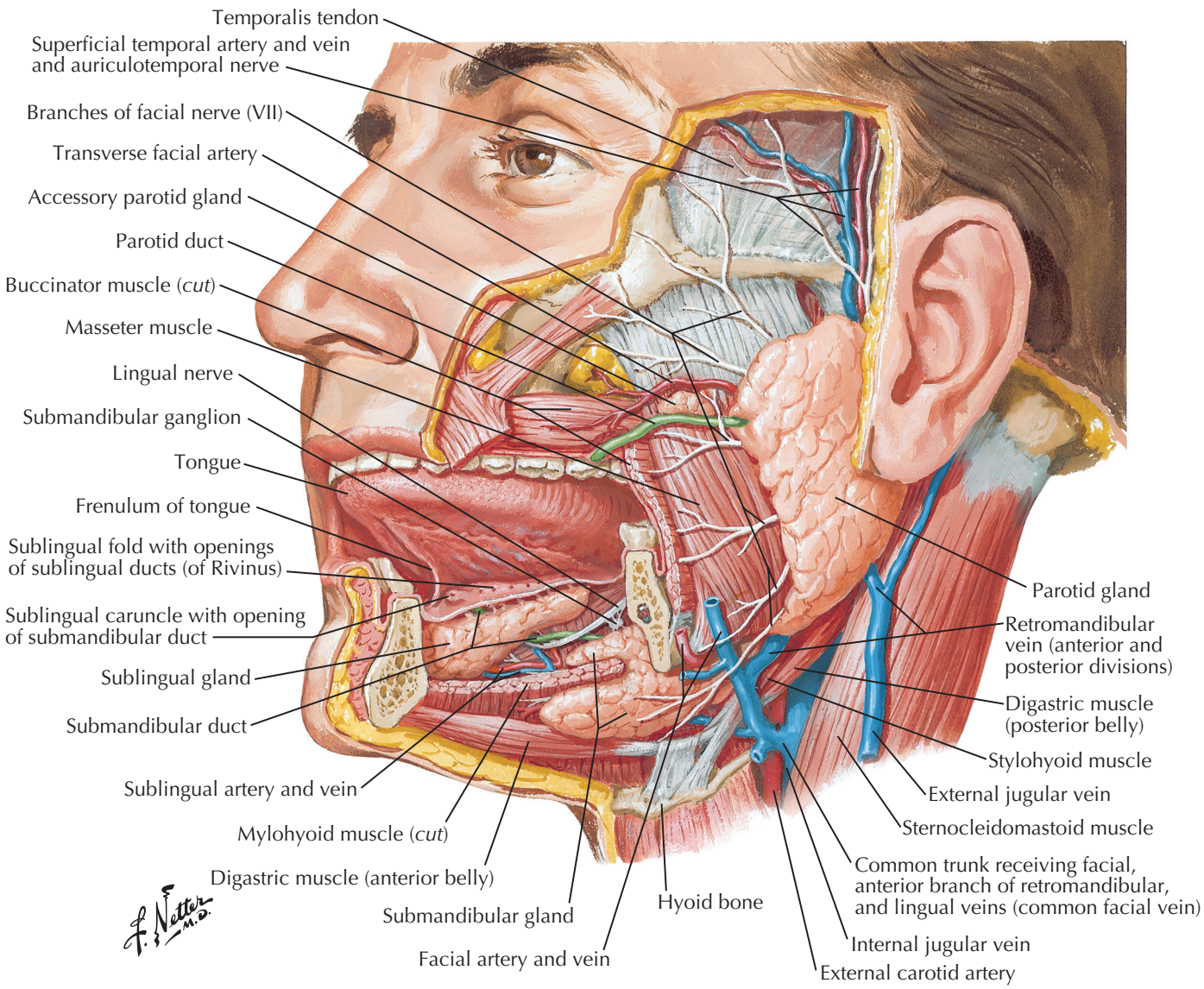
Growth of frontal and maxillary sinuses throughout life



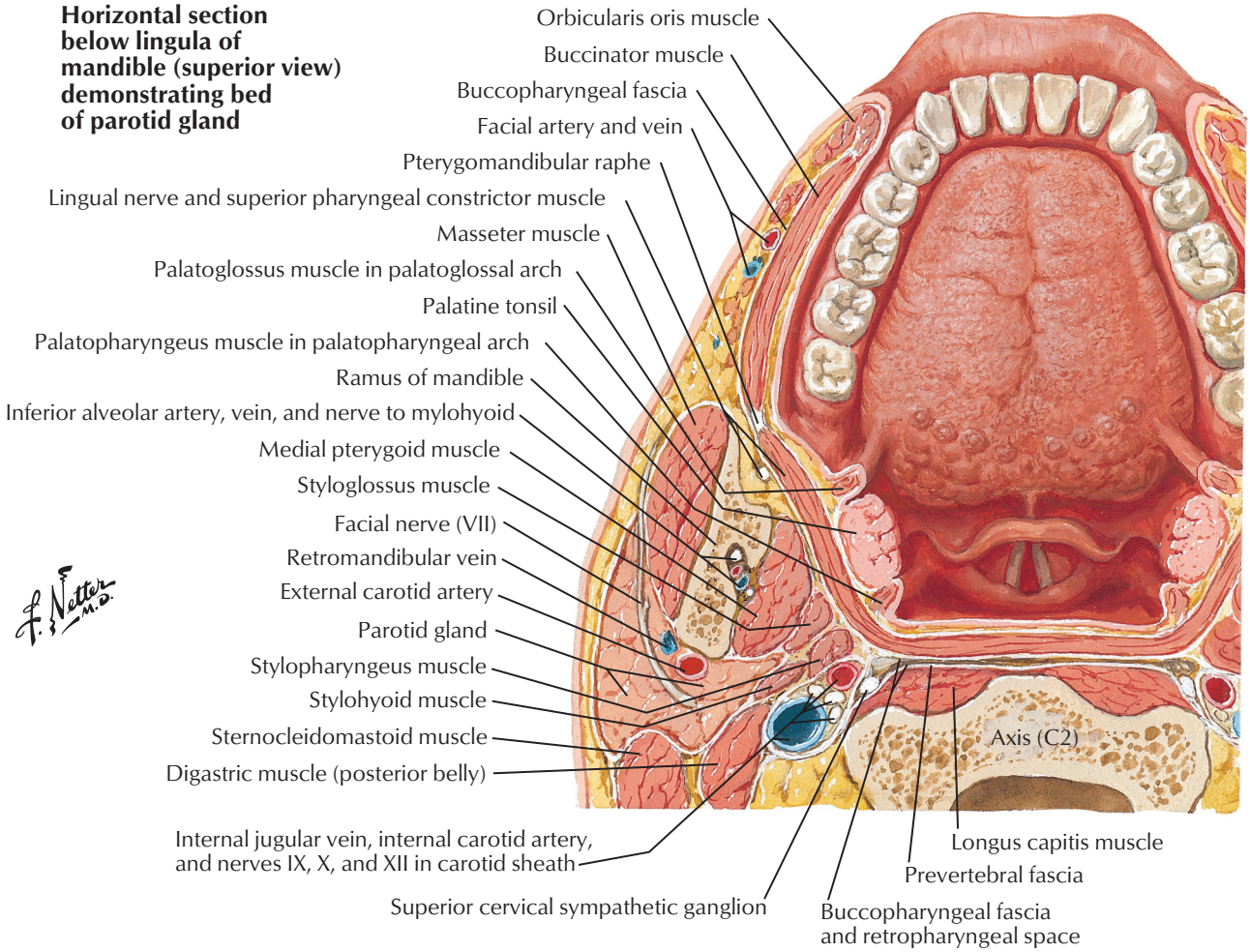
F. Netter M.D.

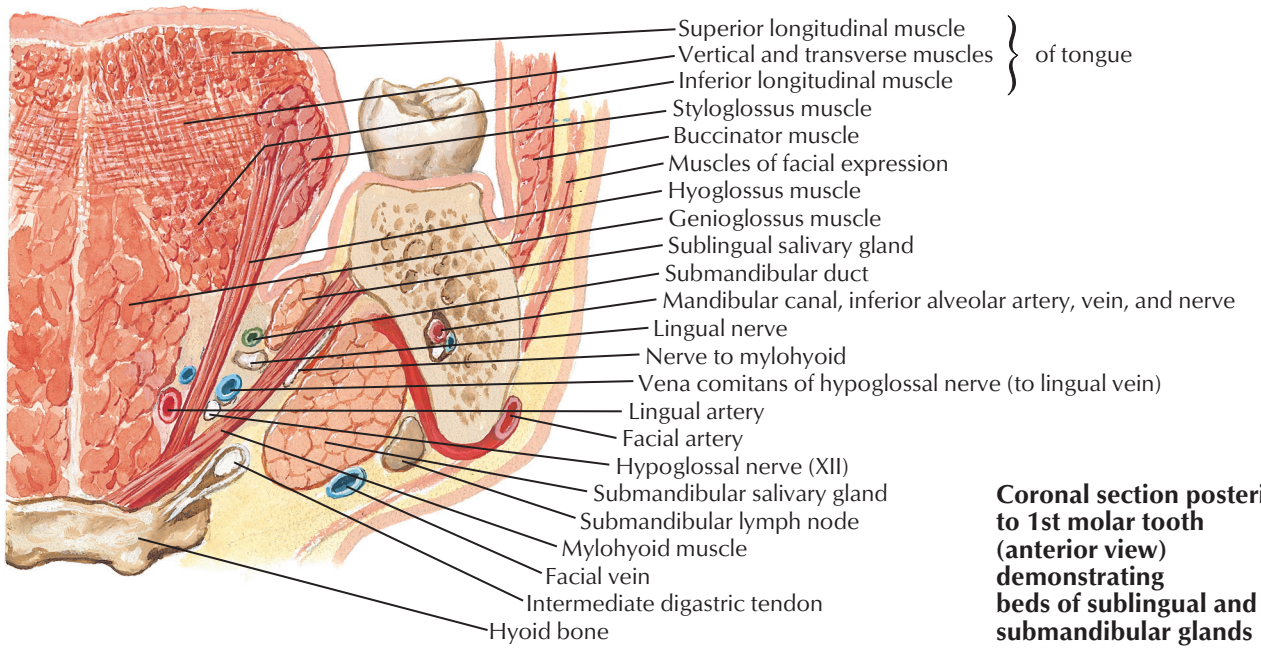
Salivary Glands

See also Plates 24, 134, 135



Horizontal section below lingula of mandible (superior view) demonstrating bed of parotid gland

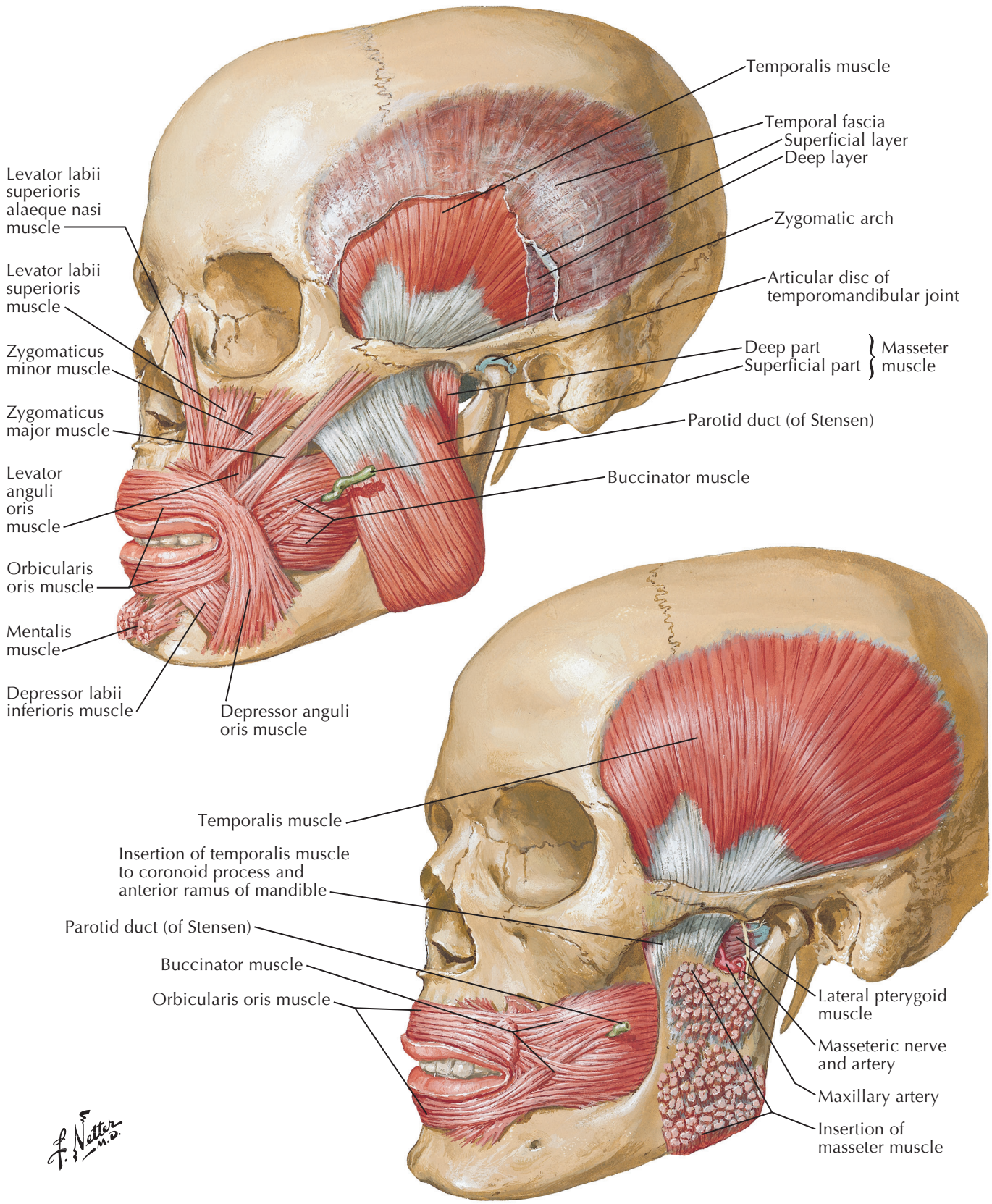


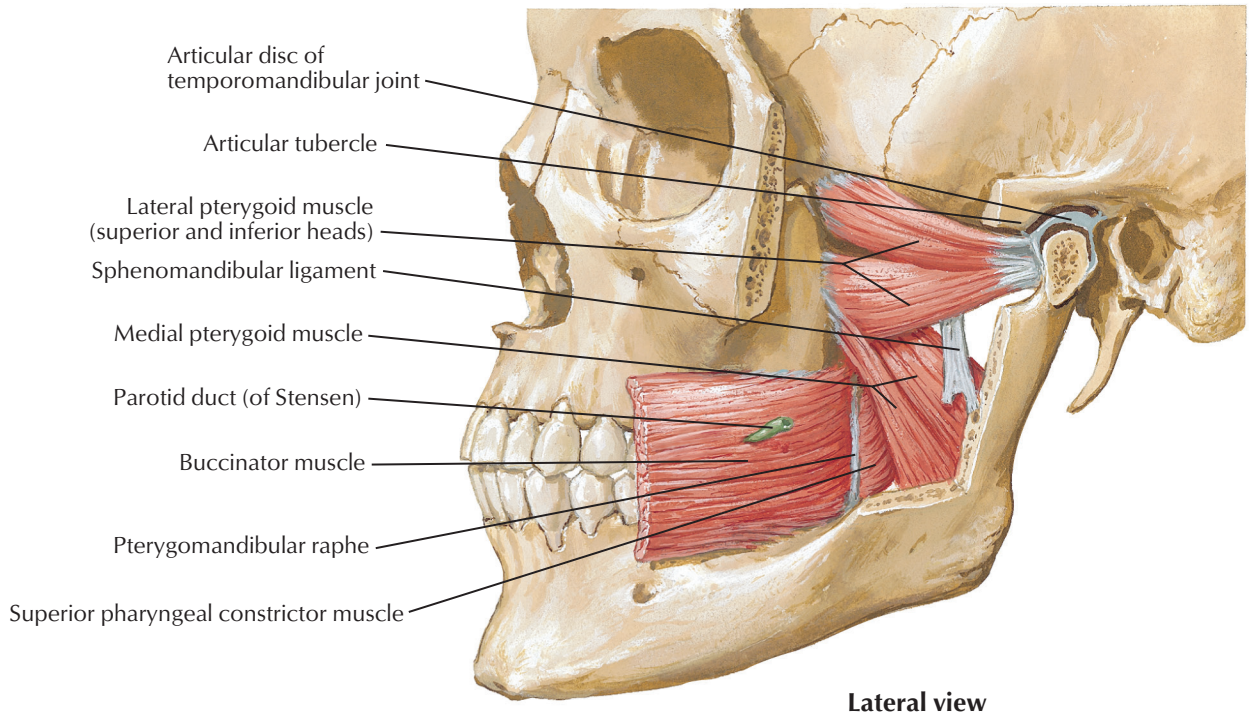


Coronal section posterior to 1st molar tooth (anterior view) demonstrating beds of sublingual and submandibular glands

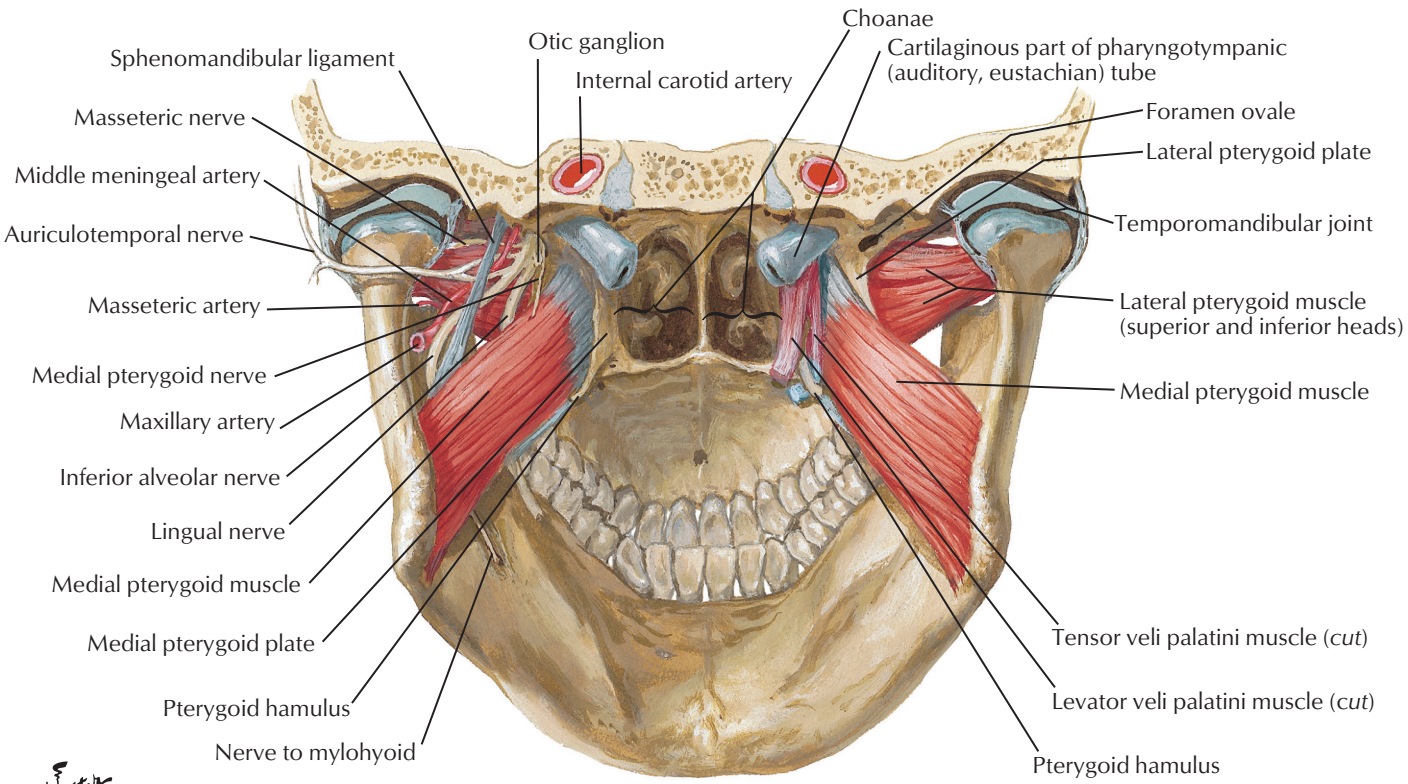
Muscles Involved in Mastication

For facial muscles see Plate 25





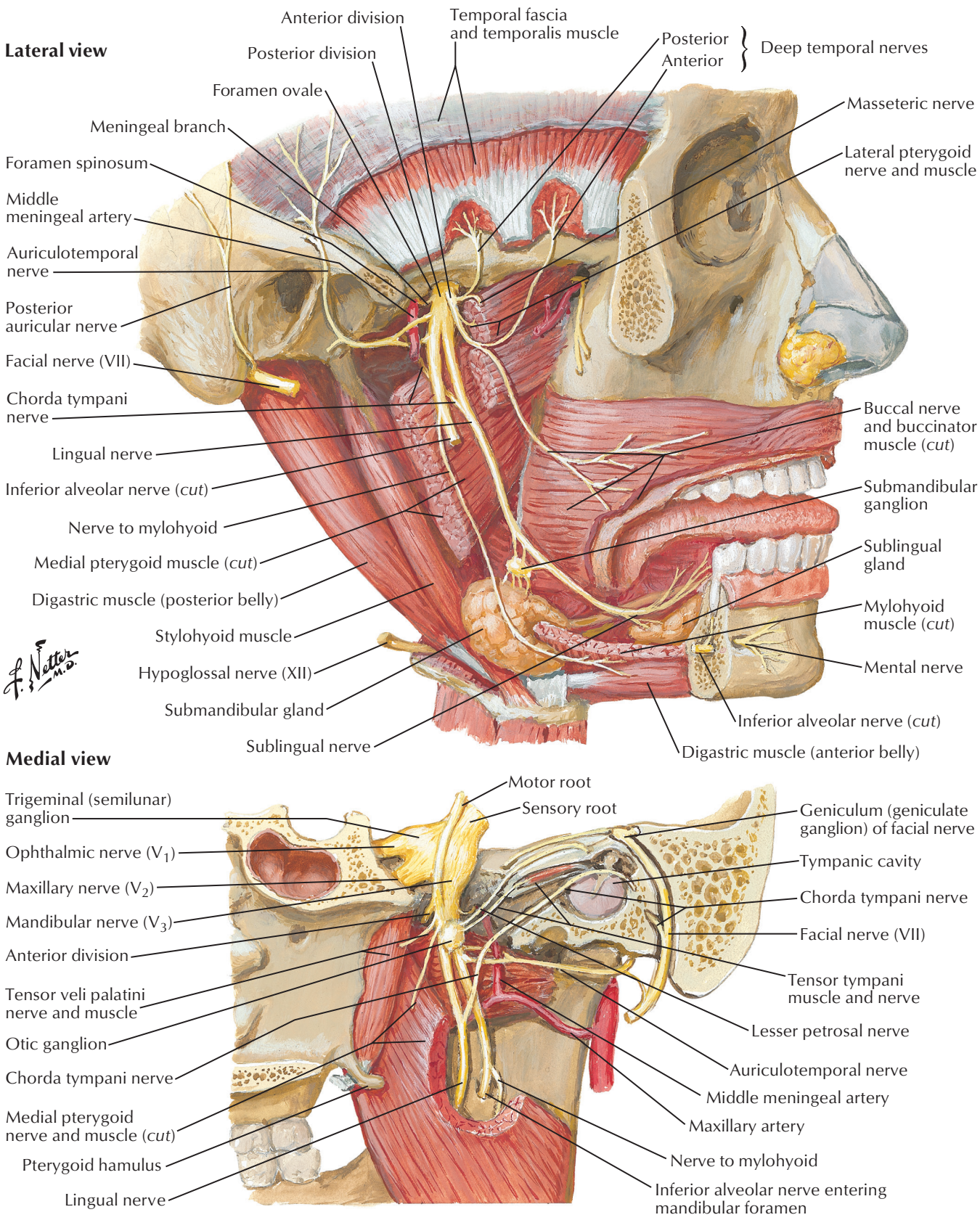
Lateral view



Posterior view

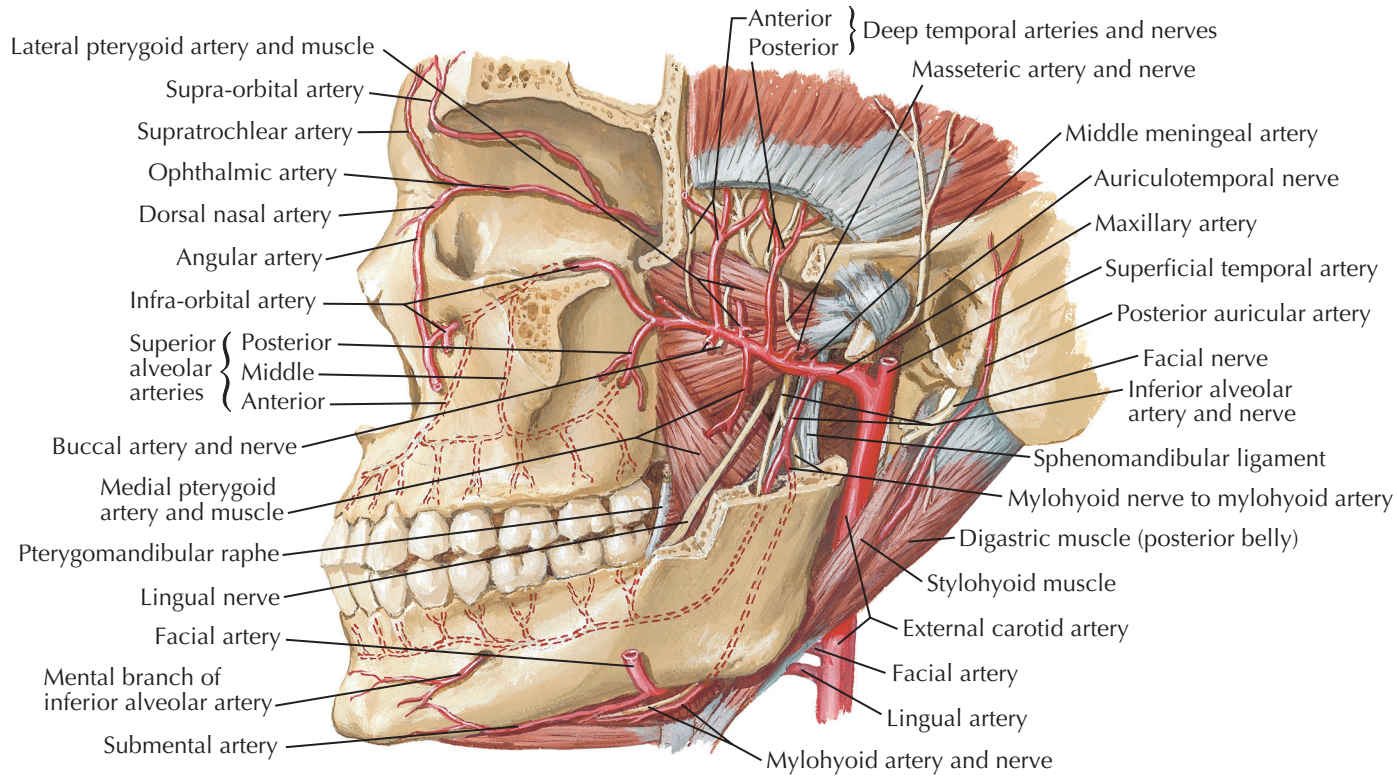
Mandibular Nerve (V_3)

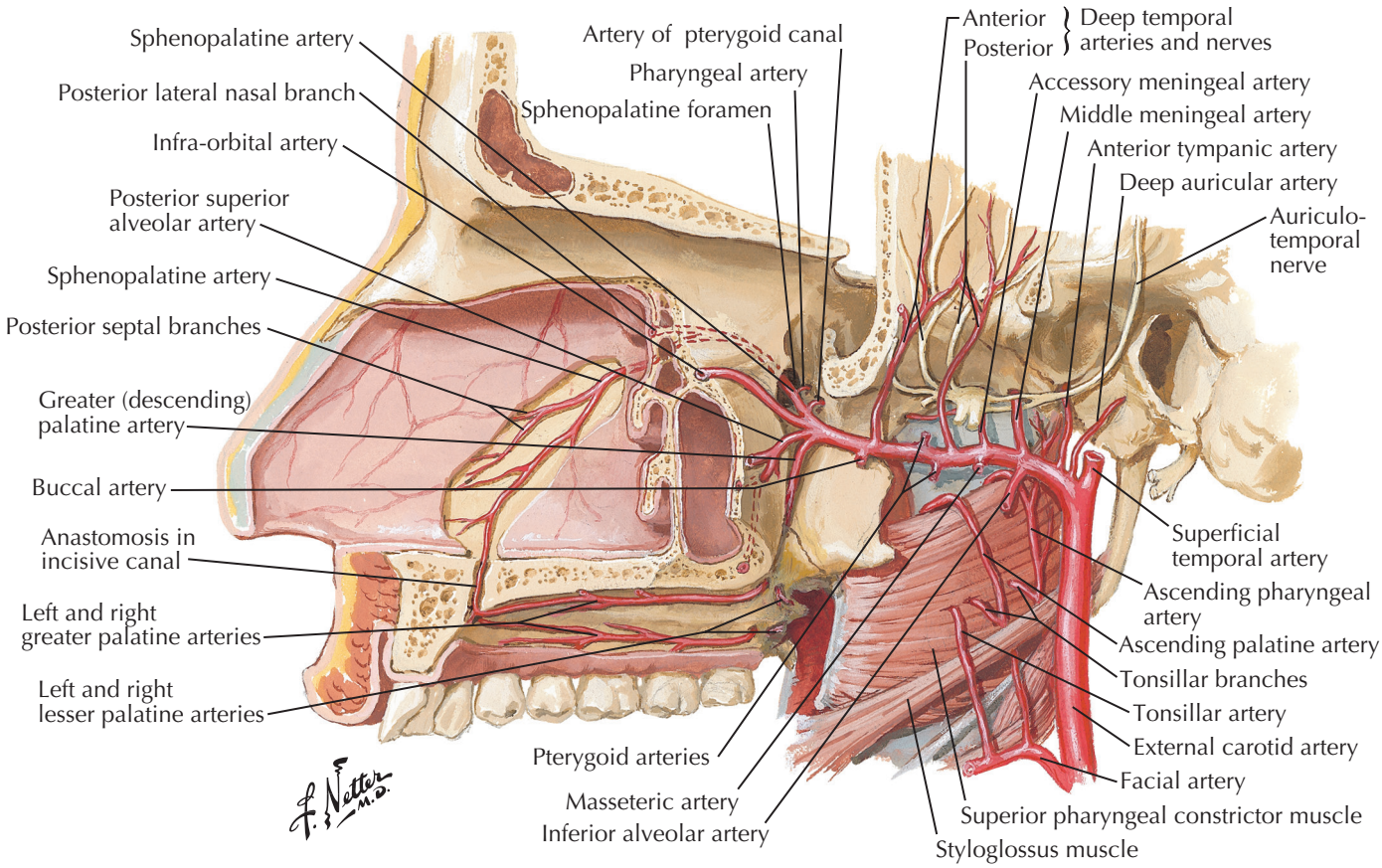
See also Plates 71, 123



Maxillary Artery

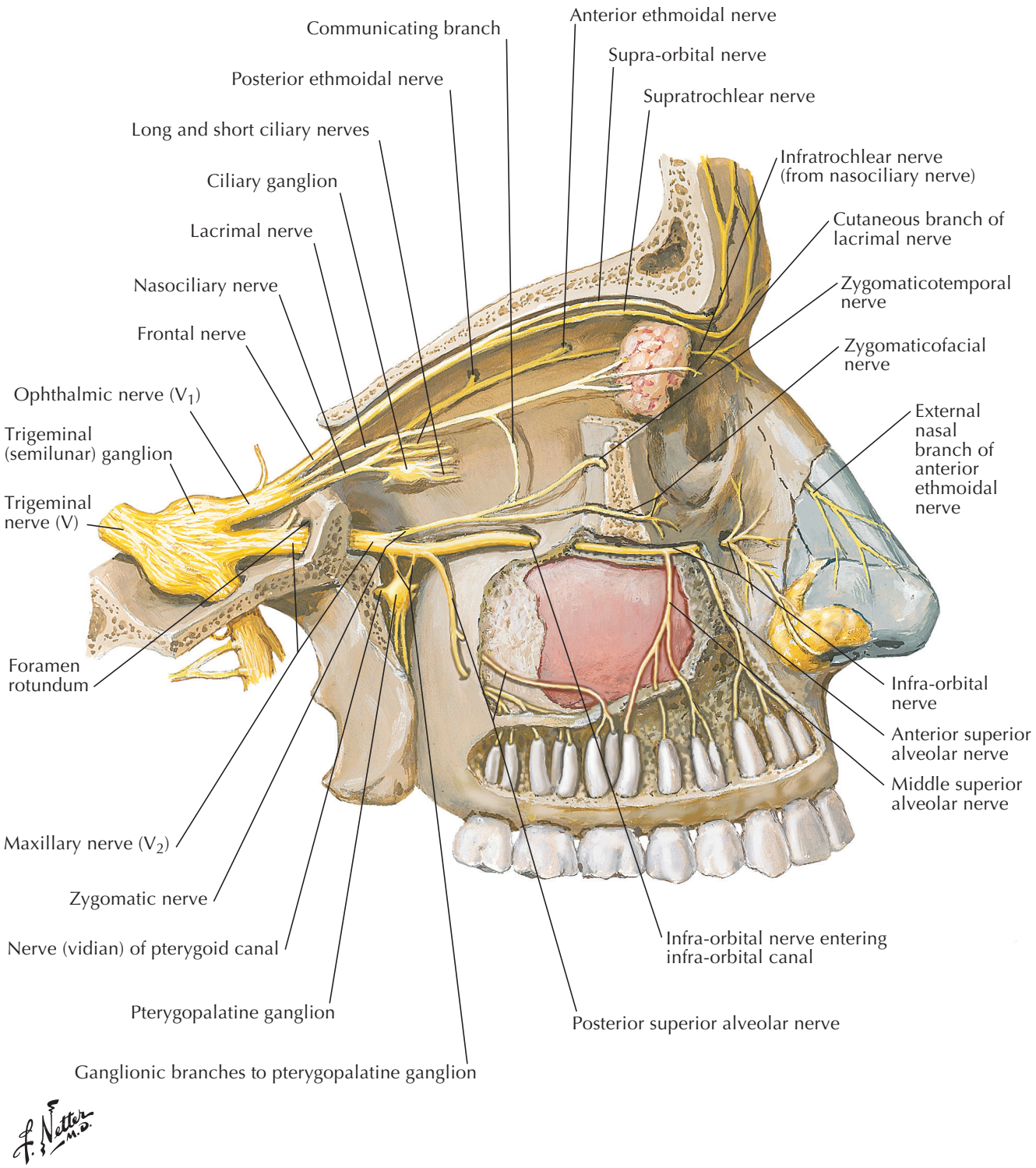
See also Plates 34, 72





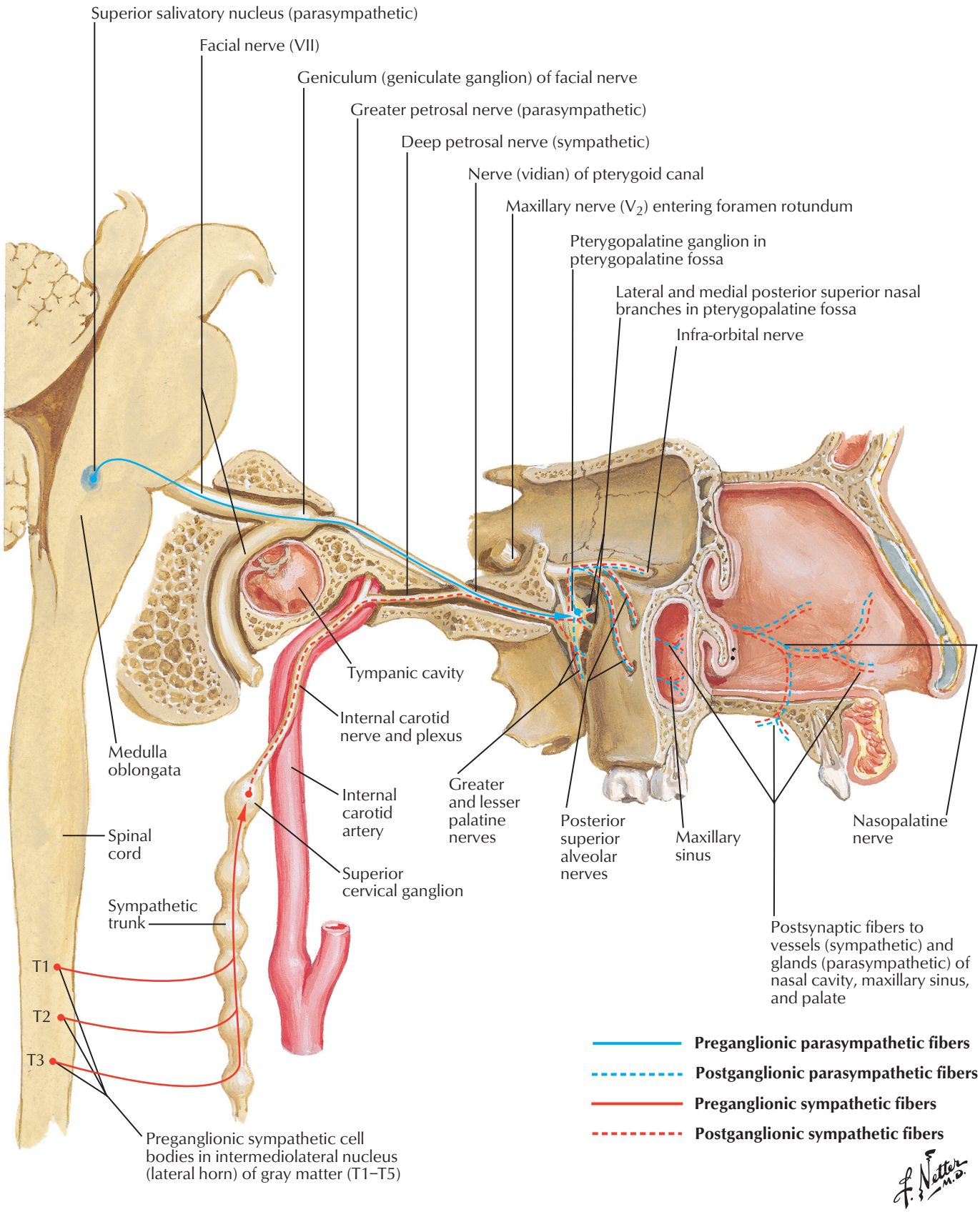
Ophthalmic (V_1) and Maxillary (V_2) Nerves

See also Plate 44



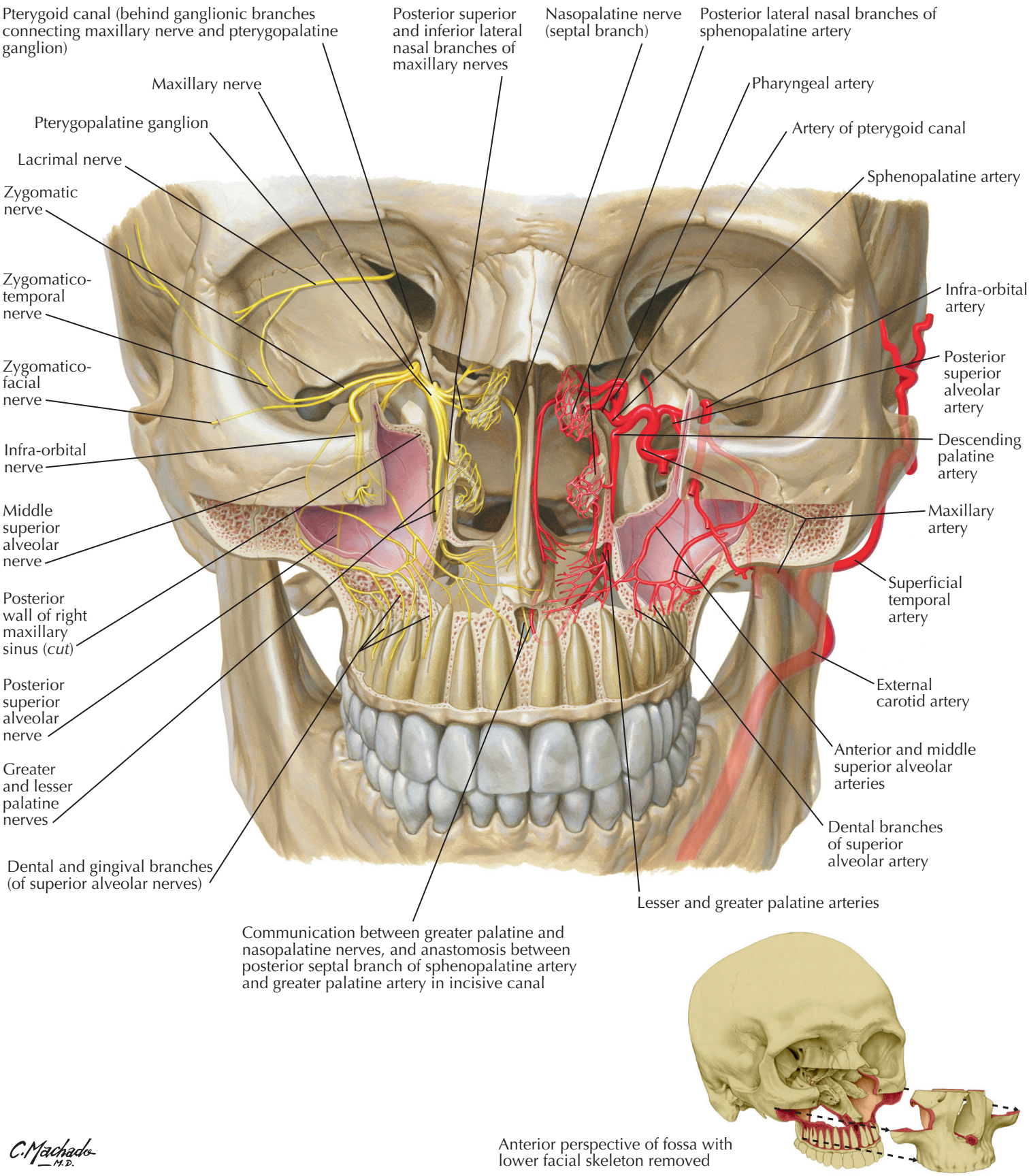
Autonomic Innervation of Nasal Cavity

See also Plates 123, 132, 134



Pterygopalatine Fossa

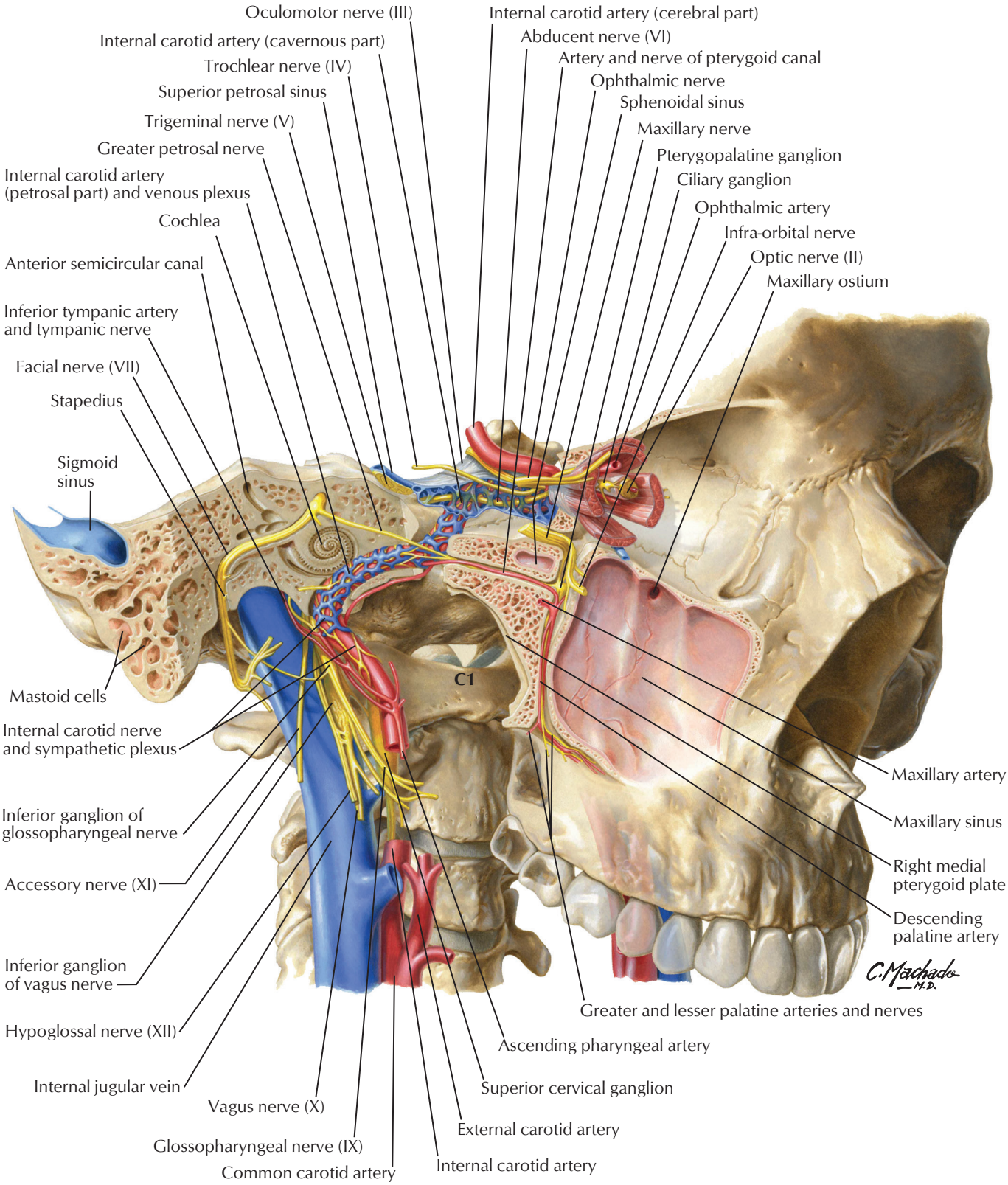
See also Plates 39, 41, 52

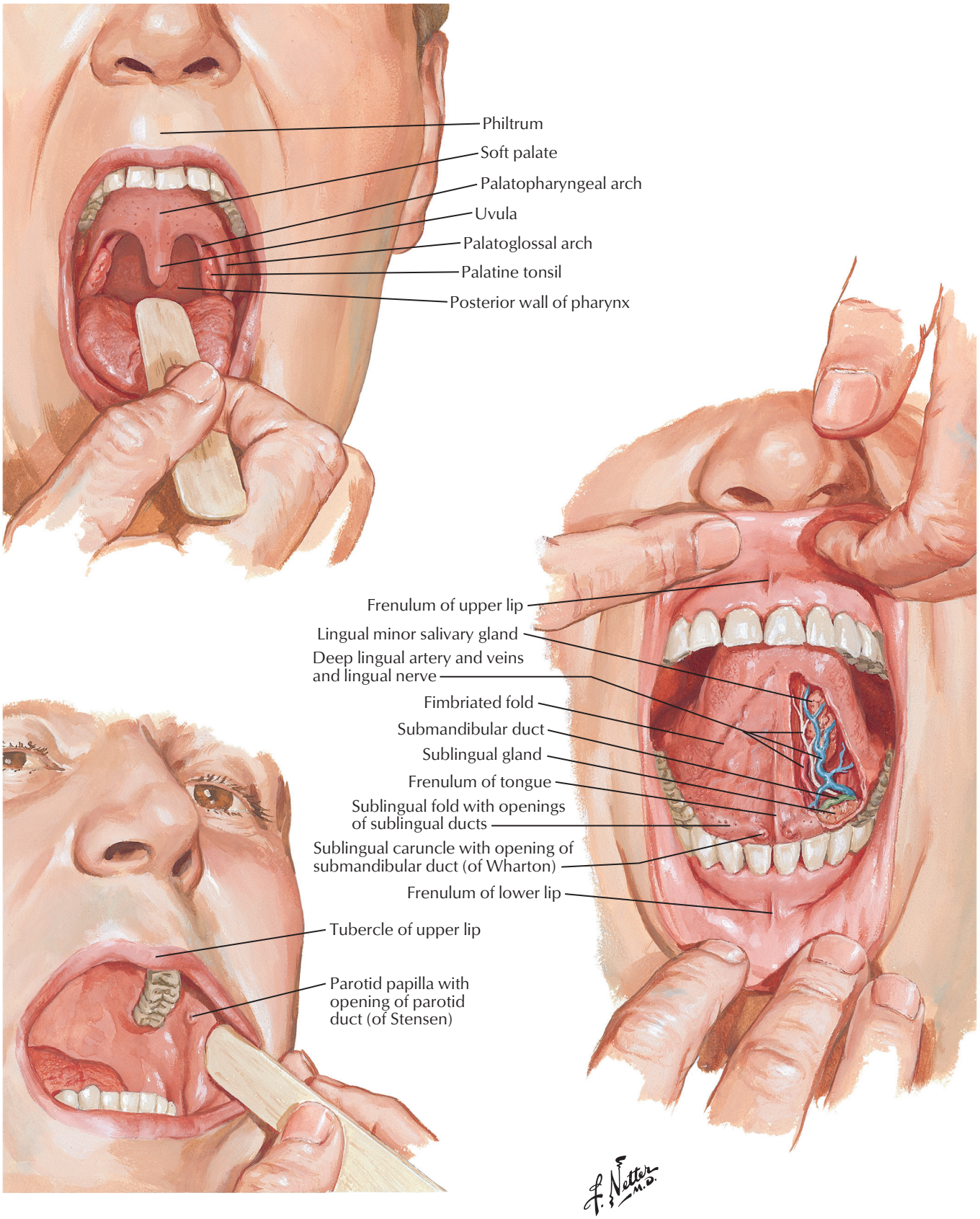


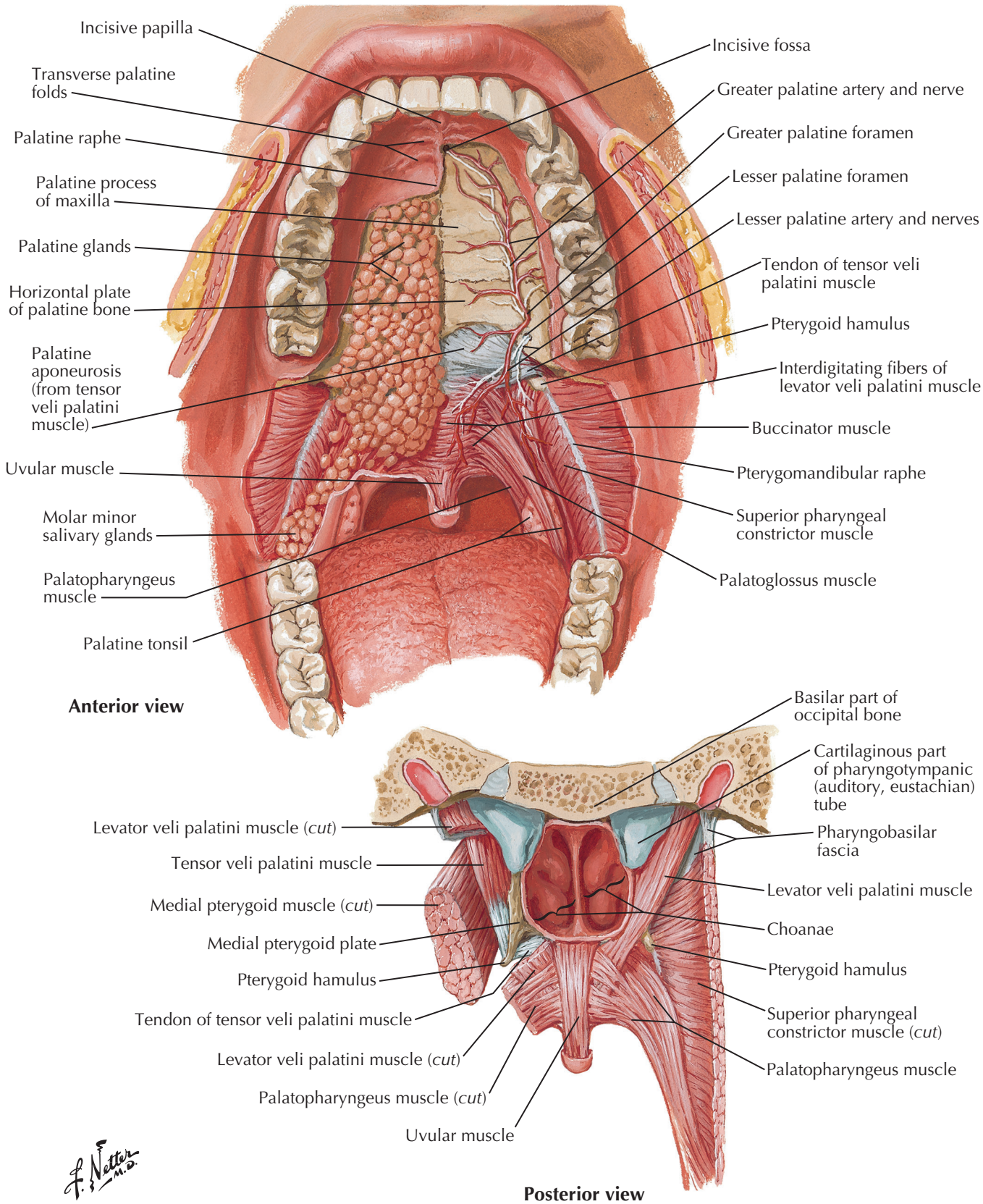
Anterior perspective of fossa with lower facial skeleton removed

Orientation of Nerves and Vessels of the Cranial Base

See also Plates 105, 132, 137

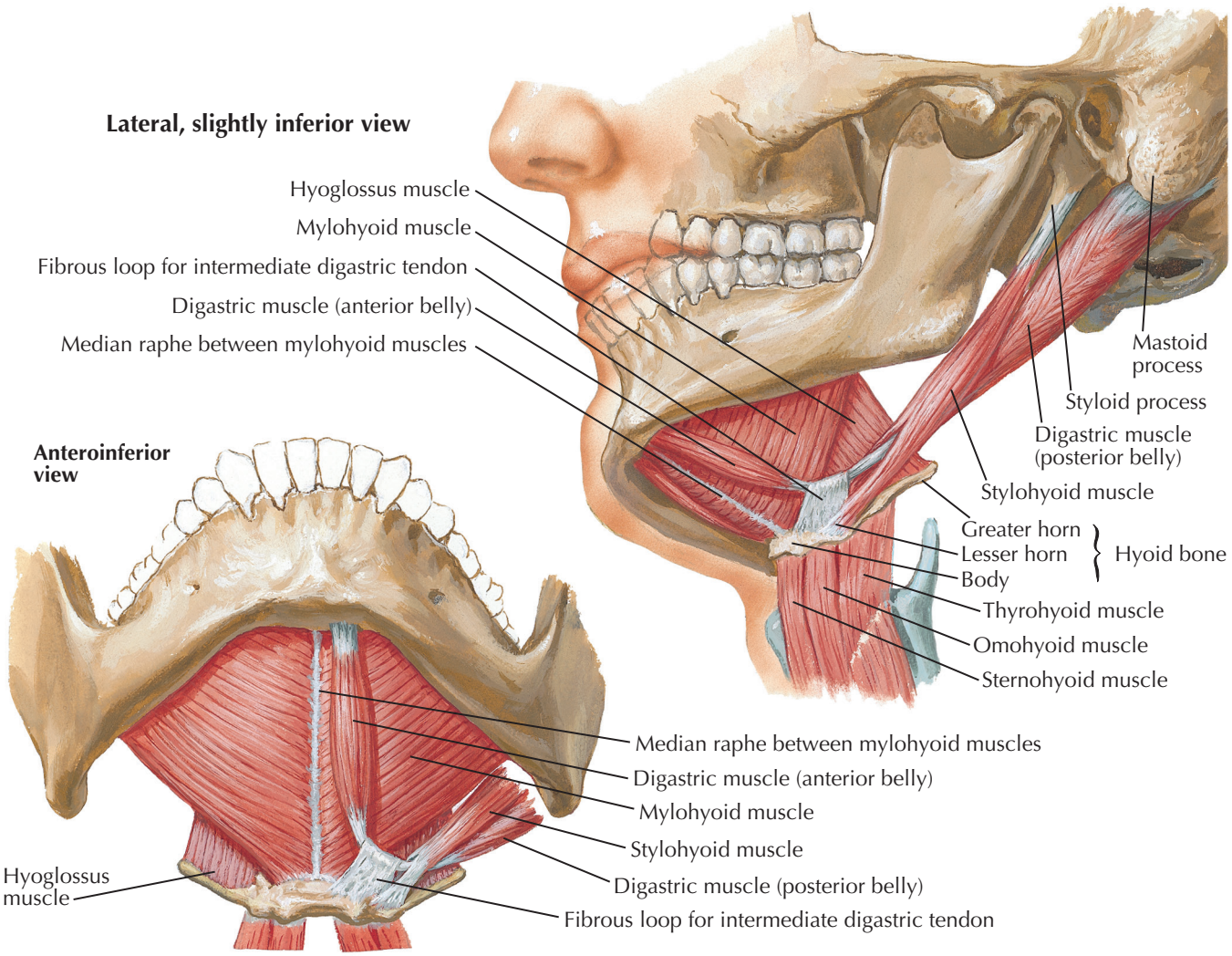


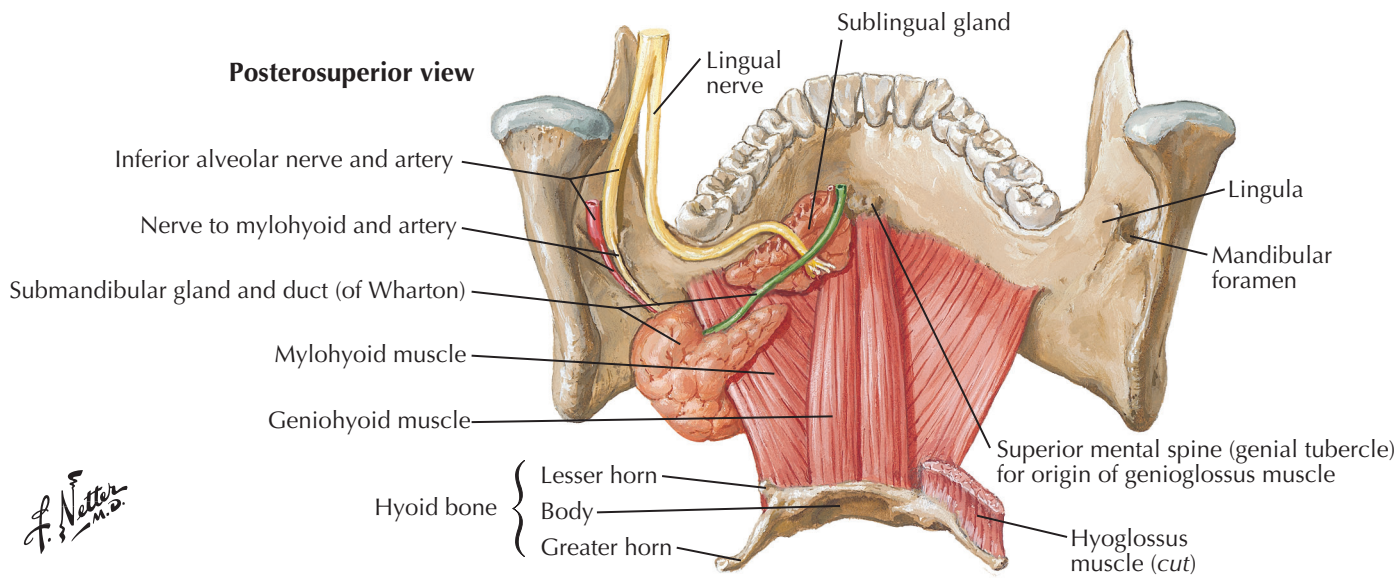

Philtrum
Soft palate
Palatopharyngeal arch
Uvula
Palatoglossal arch
Palatine tonsil
Posterior wall of pharynx
Frenulum of upper lip
Lingual minor salivary gland
Deep lingual artery and veins and lingual nerve
Fimbriated fold
Submandibular duct
Sublingual gland
Frenulum of tongue
Sublingual fold with openings of sublingual ducts
Sublingual caruncle with opening of submandibular duct (of Wharton)
Frenulum of lower lip
Tubercle of upper lip
Parotid papilla with opening of parotid duct (of Stensen)

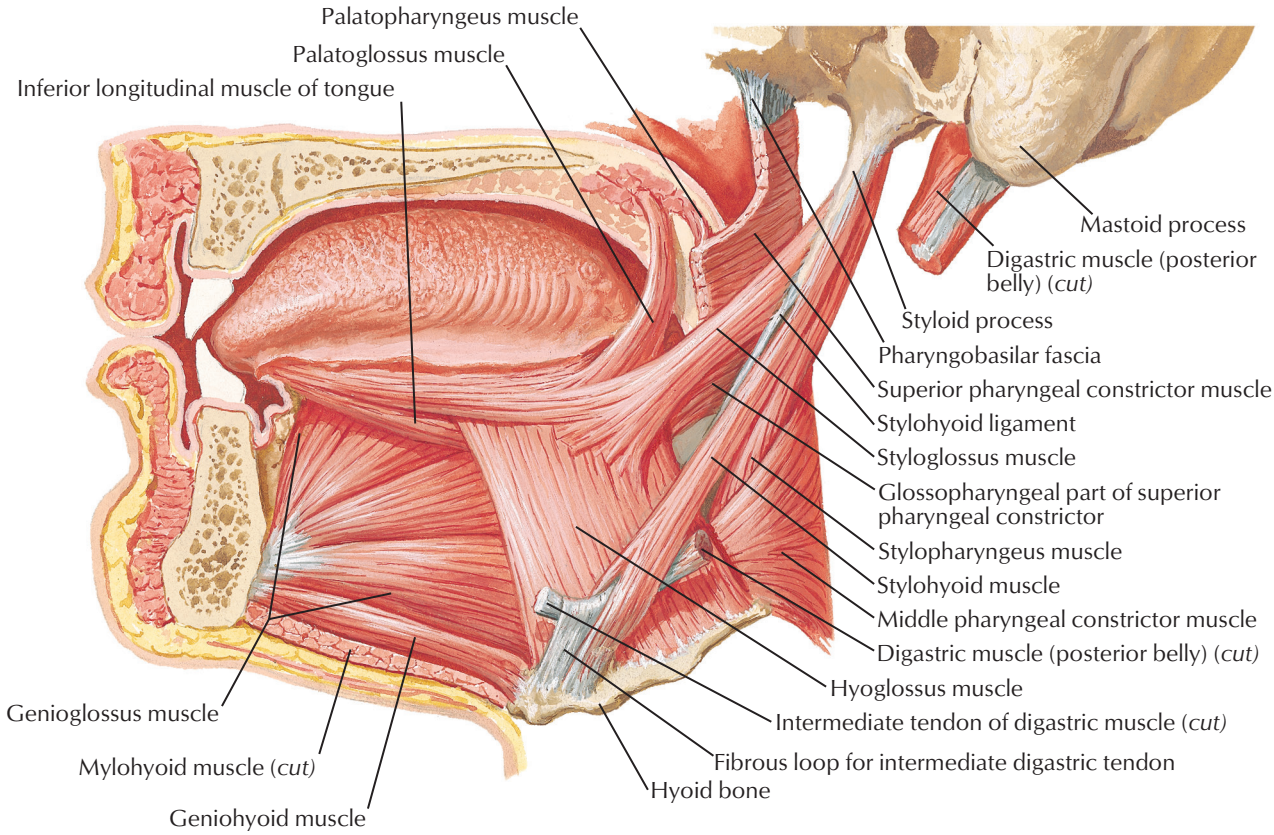

Incisive papilla
Transverse palatine folds
Palatine raphe
Palatine process of maxilla
Palatine glands
Horizontal plate of palatine bone
Palatine aponeurosis (from tensor veli palatini muscle)
Uvular muscle
Molar minor salivary glands
Palatopharyngeus muscle
Palatine tonsil
Incisive fossa
Greater palatine artery and nerve
Greater palatine foramen
Lesser palatine foramen
Lesser palatine artery and nerves
Tendon of tensor veli palatini muscle
Pterygoid hamulus
Interdigitating fibers of levator veli palatini muscle
Buccinator muscle
Pterygomandibular raphe
Superior pharyngeal constrictor muscle
Palatoglossus muscle
Anterior view
Basilar part of occipital bone
Cartilaginous part of pharyngotympanic (auditory, eustachian) tube
Levator veli palatini muscle (cut)
Tensor veli palatini muscle
Medial pterygoid muscle (cut)
Medial pterygoid plate
Pterygoid hamulus
Tendon of tensor veli palatini muscle
Levator veli palatini muscle (cut)
Palatopharyngeus muscle (cut)
Uvular muscle
Pharyngobasilar fascia
Levator veli palatini muscle
Choanae
Pterygoid hamulus
Superior pharyngeal constrictor muscle (cut)
Palatopharyngeus muscle
Posterior view

Floor of Oral Cavity

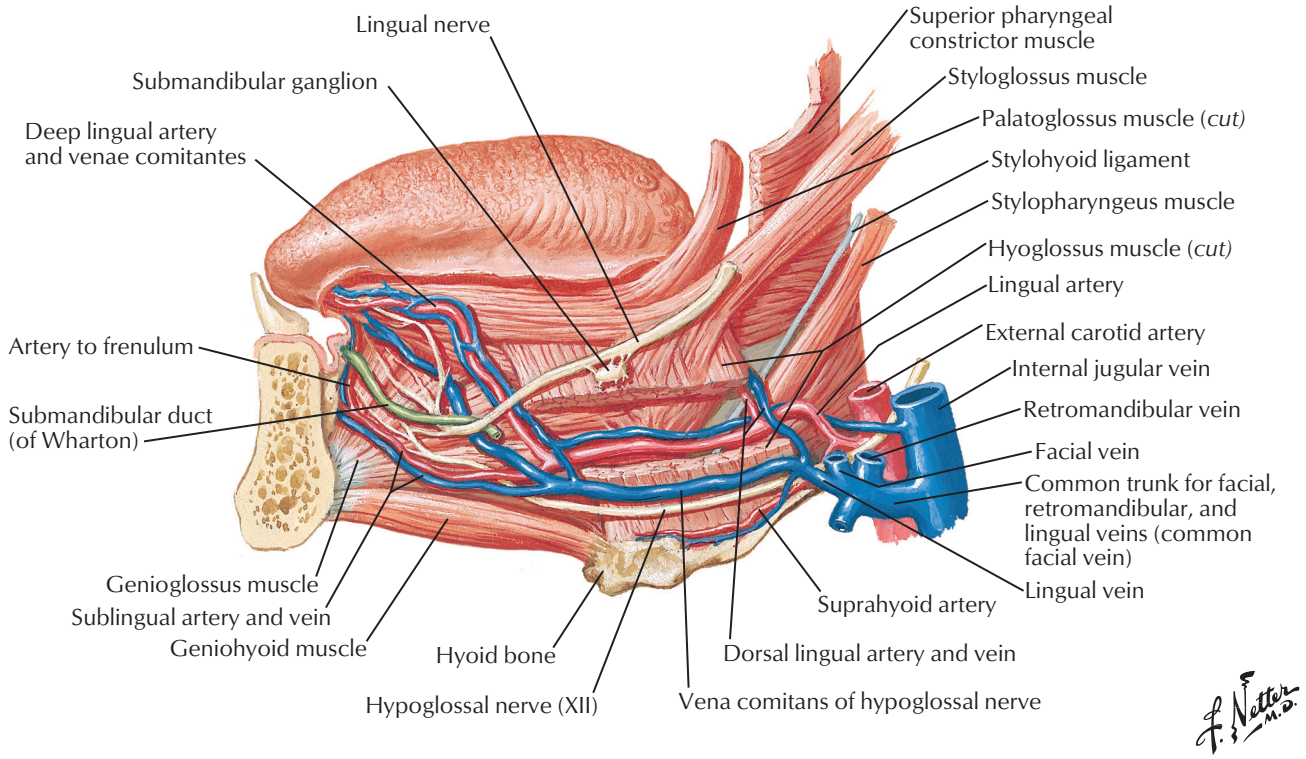
See also Plate 28

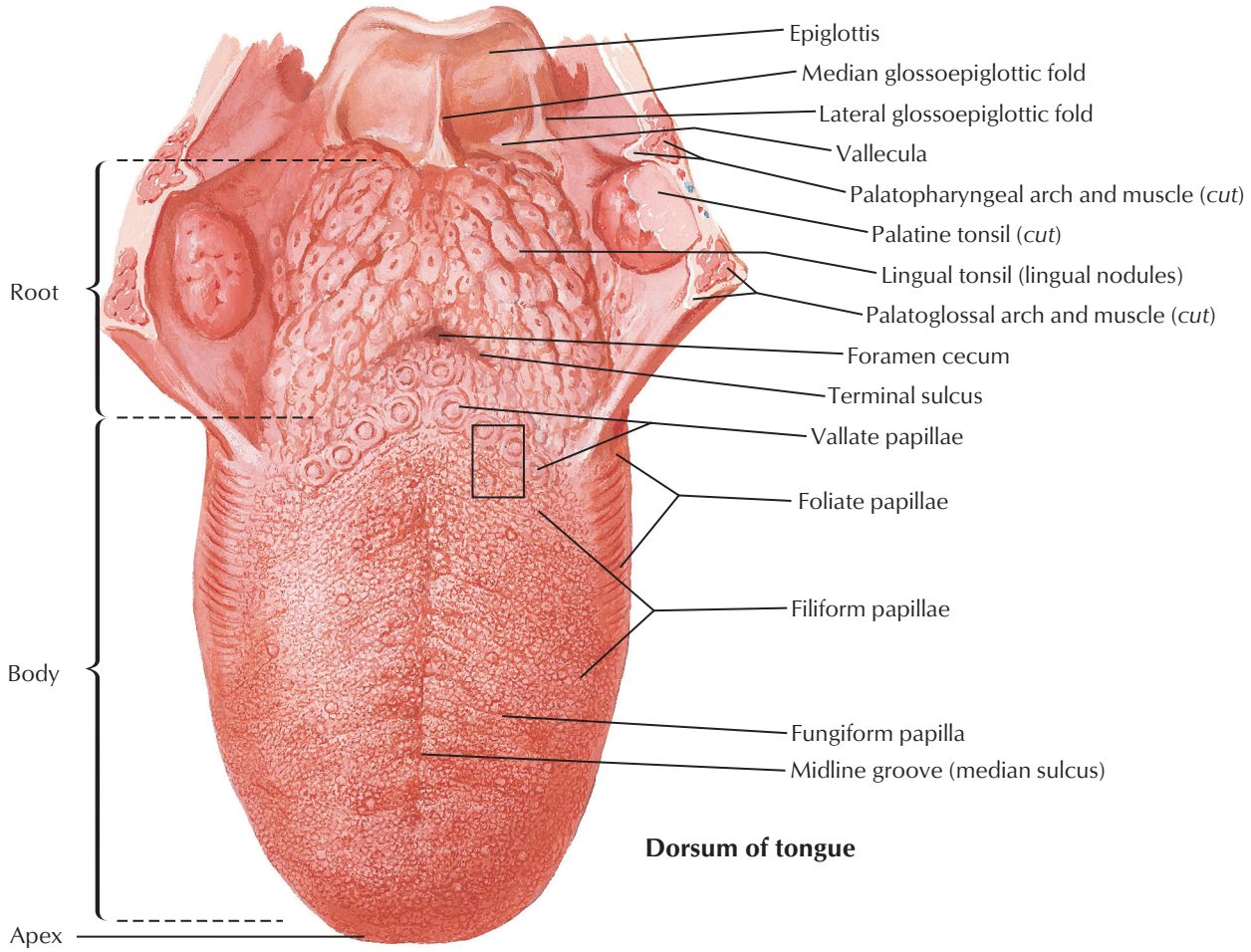




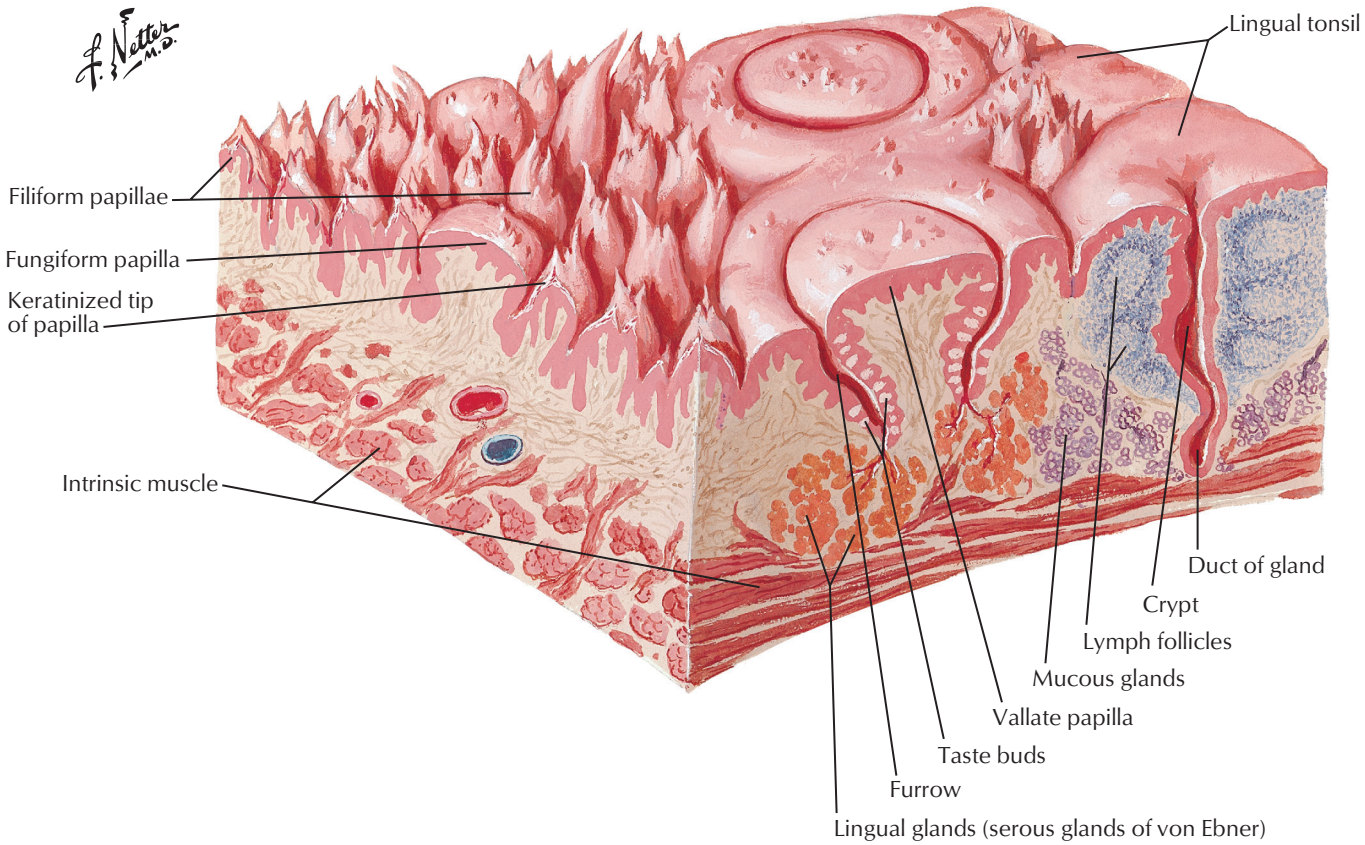


Lateral view





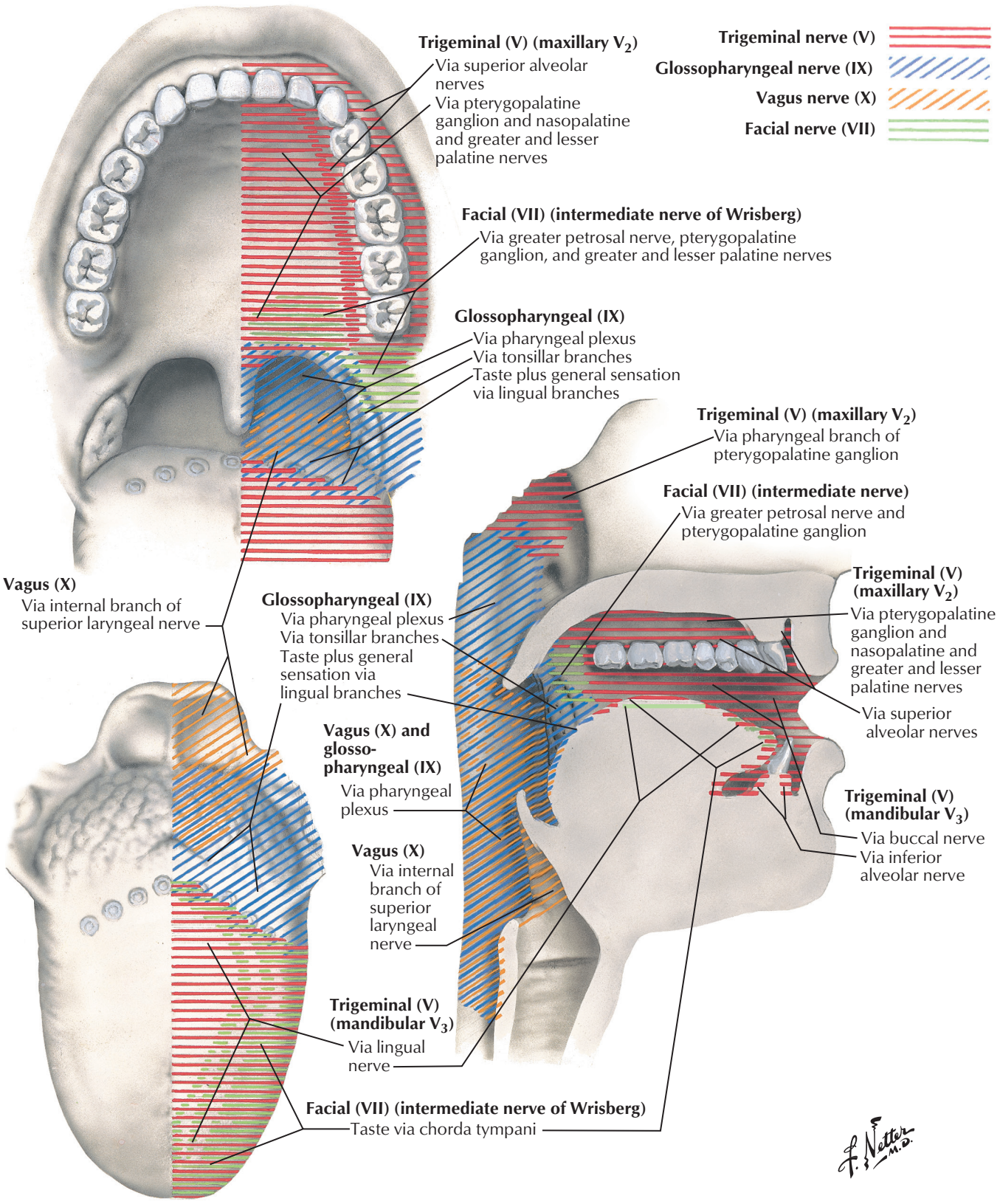
Dorsum of tongue

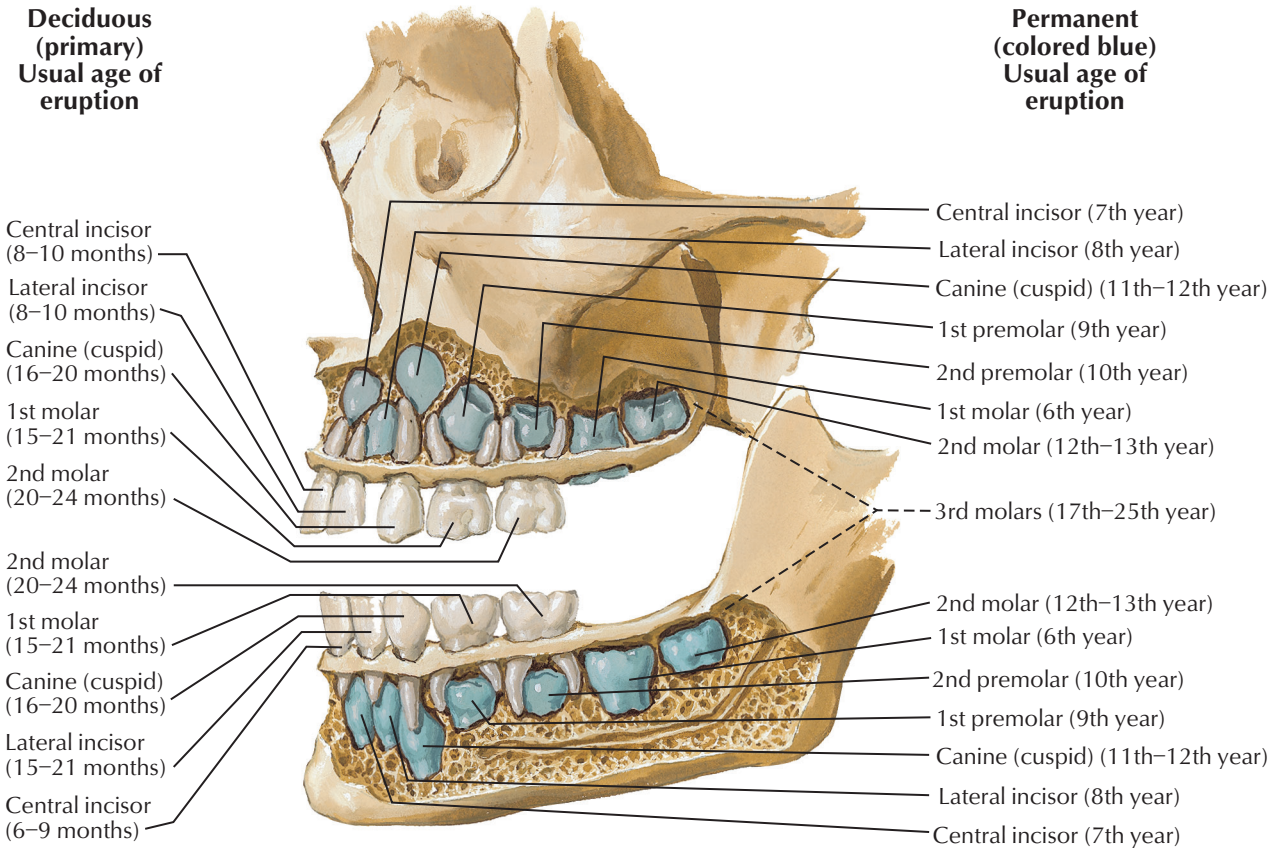


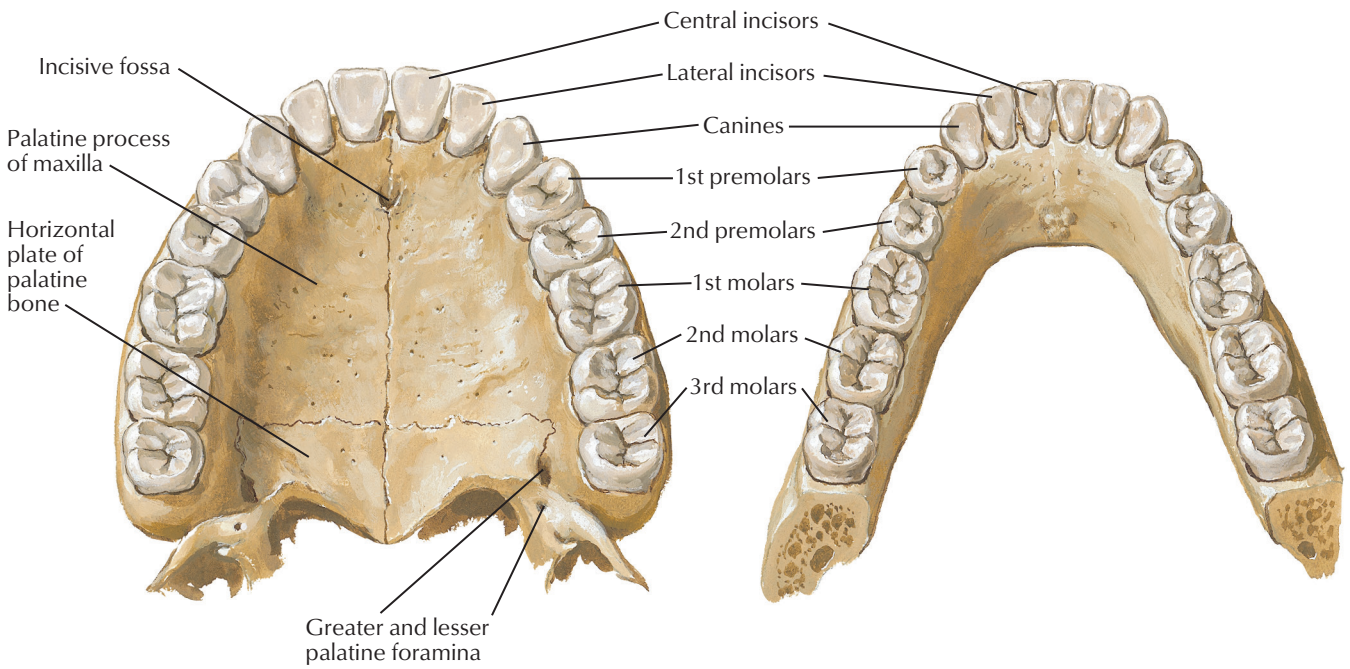
Schematic stereogram: area indicated above

Afferent Innervation of Oral Cavity and Pharynx

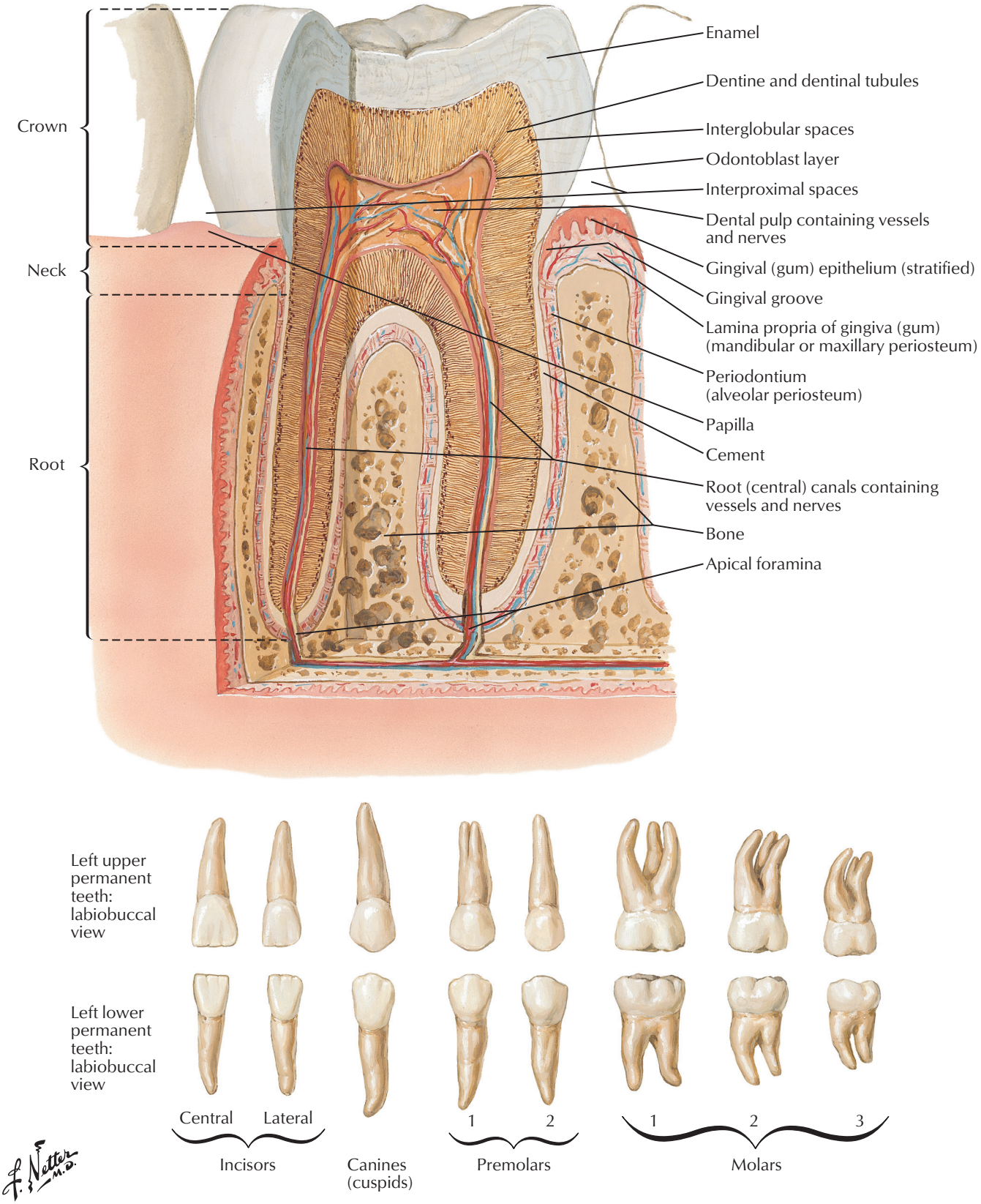
See also Plates 126, 134, 136

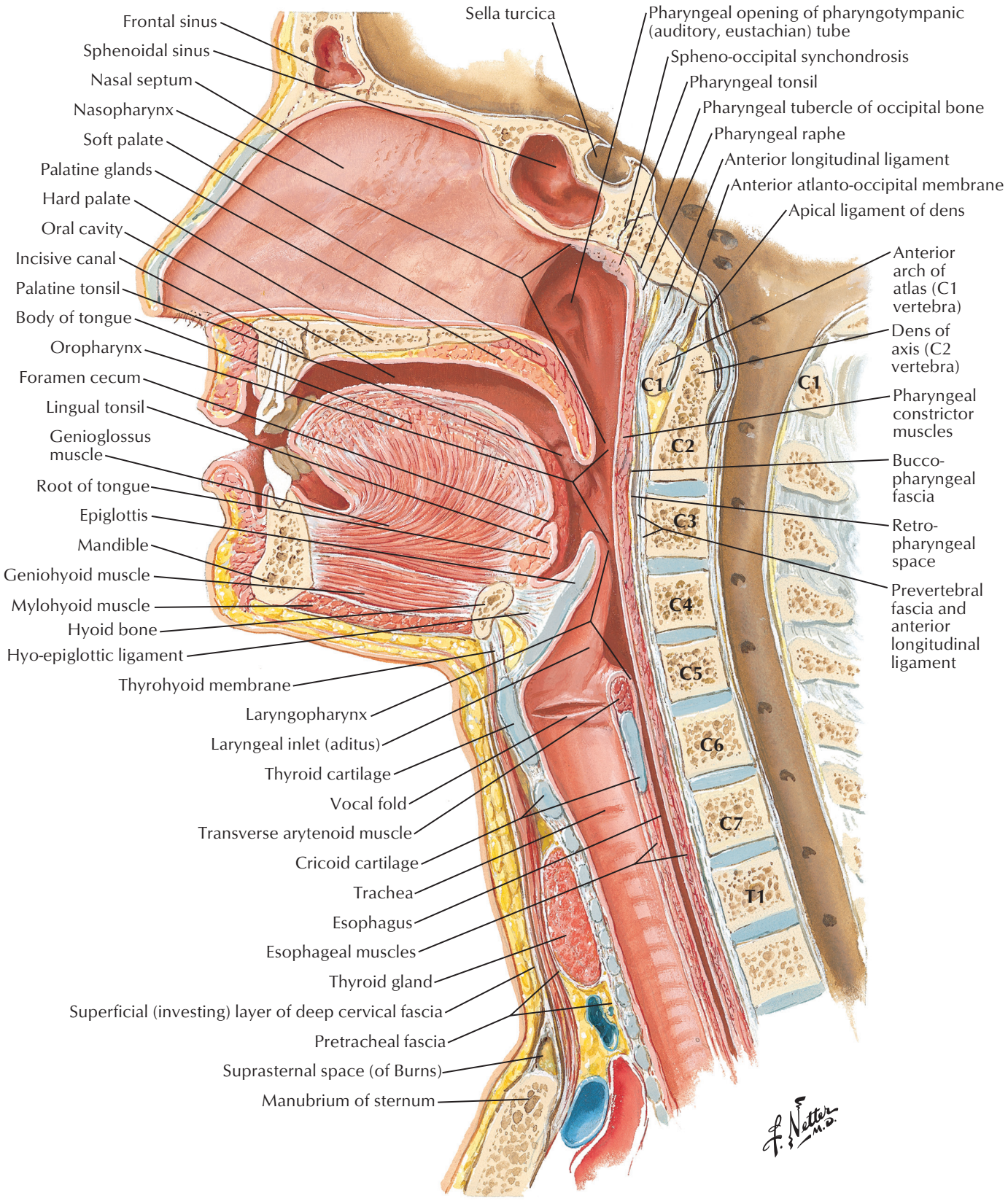


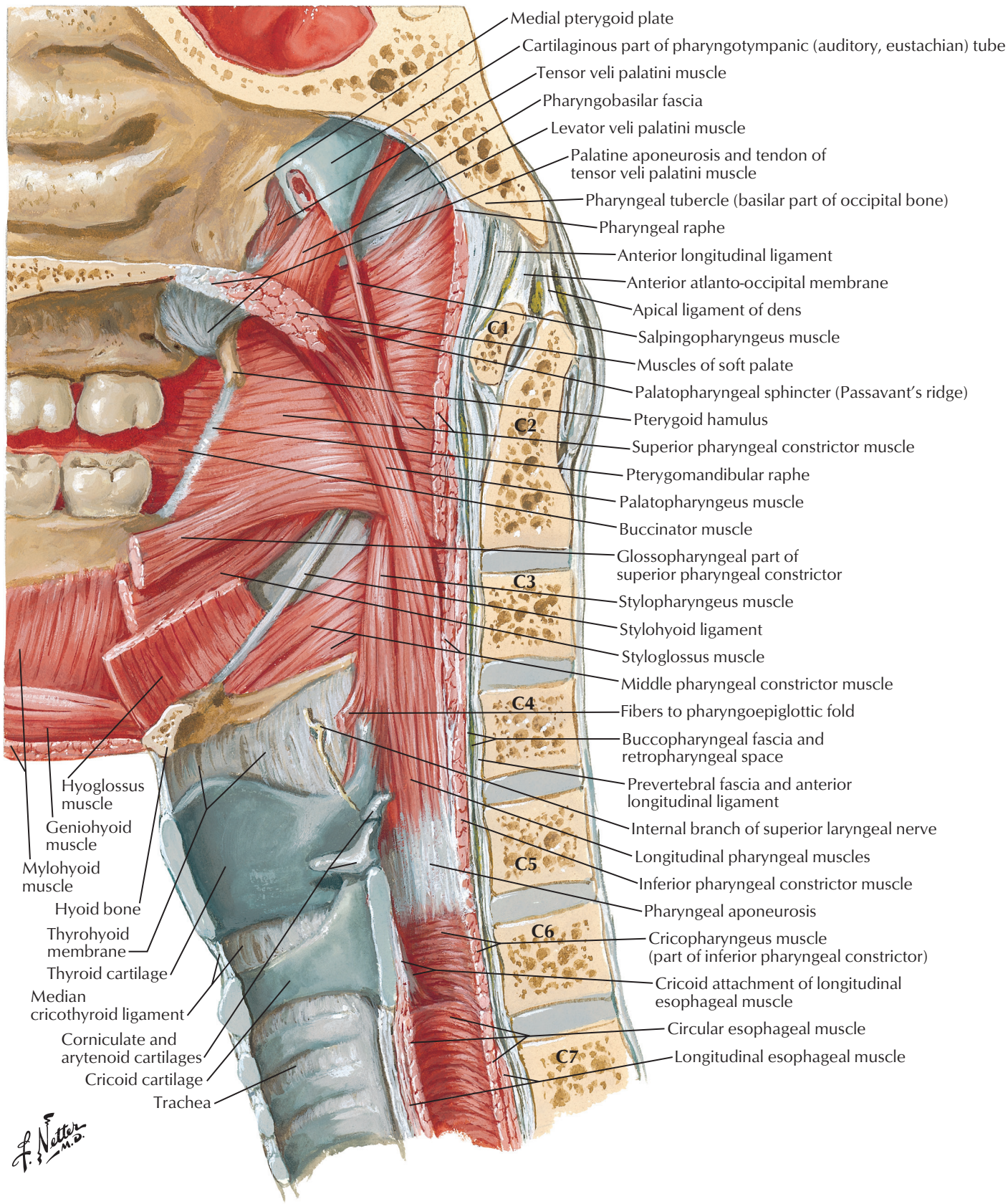


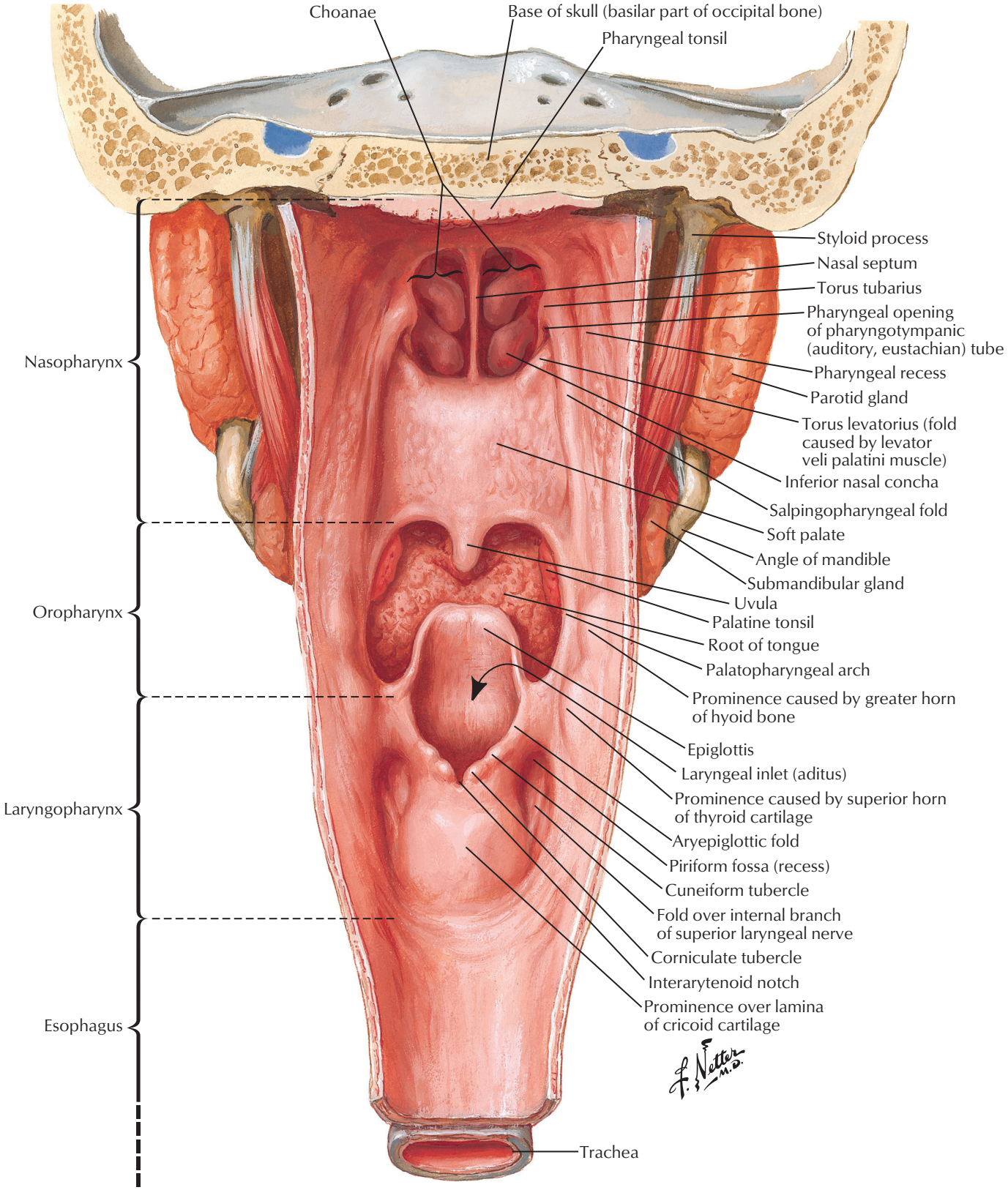


Upper permanent teeth **Lower permanent teeth**


Crown
Neck
Root
Enamel
Dentine and dentinal tubules
Interglobular spaces
Odontoblast layer
Interproximal spaces
Dental pulp containing vessels and nerves
Gingival (gum) epithelium (stratified)
Gingival groove
Lamina propria of gingiva (gum) (mandibular or maxillary periosteum)
Periodontium (alveolar periosteum)
Papilla
Cement
Root (central) canals containing vessels and nerves
Bone
Apical foramina
Left upper permanent teeth: labiobuccal view
Left lower permanent teeth: labiobuccal view
Central
Lateral
1
2
1
2
3
Incisors
Canines (cuspids)
Premolars
Molars

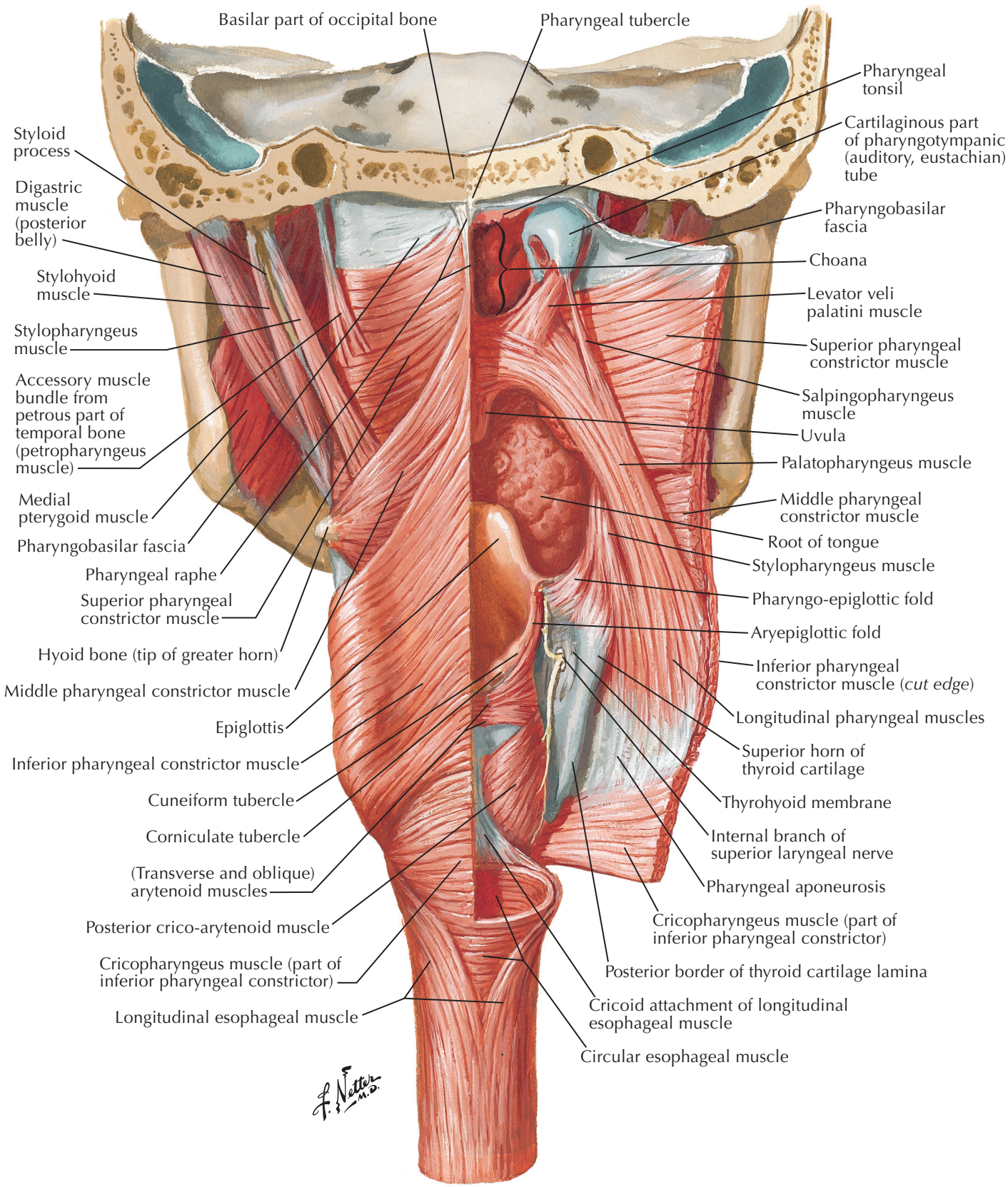

Frontal sinus
Sphenoidal sinus
Nasal septum
Nasopharynx
Soft palate
Palatine glands
Hard palate
Oral cavity
Incisive canal
Palatine tonsil
Body of tongue
Oropharynx
Foramen cecum
Lingual tonsil
Genioglossus muscle
Root of tongue
Epiglottis
Mandible
Geniohyoid muscle
Mylohyoid muscle
Hyoid bone
Hyo-epiglottic ligament
Thyrohyoid membrane
Laryngopharynx
Laryngeal inlet (aditus)
Thyroid cartilage
Vocal fold
Transverse arytenoid muscle
Cricoid cartilage
Trachea
Esophagus
Esophageal muscles
Thyroid gland
Superficial (investing) layer of deep cervical fascia
Pretracheal fascia
Suprasternal space (of Burns)
Manubrium of sternum
Sella turcica
Pharyngeal opening of pharyngotympanic (auditory, eustachian) tube
Spheno-occipital synchondrosis
Pharyngeal tonsil
Pharyngeal tubercle of occipital bone
Pharyngeal raphe
Anterior longitudinal ligament
Anterior atlanto-occipital membrane
Apical ligament of dens
Anterior arch of atlas (C1 vertebra)
Dens of axis (C2 vertebra)
Pharyngeal constrictor muscles
Bucco-pharyngeal fascia
Retro-pharyngeal space
Prevertebral fascia and anterior longitudinal ligament
C1
C1
C2
C3
C4
C5
C6
C7
T1


Medial pterygoid plate
Cartilaginous part of pharyngotympanic (auditory, eustachian) tube
Tensor veli palatini muscle
Pharyngobasilar fascia
Levator veli palatini muscle
Palatine aponeurosis and tendon of tensor veli palatini muscle
Pharyngeal tubercle (basilar part of occipital bone)
Pharyngeal raphe
Anterior longitudinal ligament
Anterior atlanto-occipital membrane
Apical ligament of dens
C1
Salpingopharyngeus muscle
Muscles of soft palate
Palatopharyngeal sphincter (Passavant's ridge)
Pterygoid hamulus
C2
Superior pharyngeal constrictor muscle
Pterygomandibular raphe
Palatopharyngeus muscle
Buccinator muscle
Glossopharyngeal part of superior pharyngeal constrictor
C3
Stylopharyngeus muscle
Stylohyoid ligament
Styloglossus muscle
Middle pharyngeal constrictor muscle
C4
Fibers to pharyngoepiglottic fold
Buccopharyngeal fascia and retropharyngeal space
Prevertebral fascia and anterior longitudinal ligament
Internal branch of superior laryngeal nerve
Longitudinal pharyngeal muscles
C5
Inferior pharyngeal constrictor muscle
Pharyngeal aponeurosis
C6
Cricopharyngeus muscle (part of inferior pharyngeal constrictor)
Cricoid attachment of longitudinal esophageal muscle
Circular esophageal muscle
C7
Longitudinal esophageal muscle
Hyoglossus muscle
Geniohyoid muscle
Mylohyoid muscle
Hyoid bone
Thyrohyoid membrane
Thyroid cartilage
Median cricothyroid ligament
Corniculate and arytenoid cartilages
Cricoid cartilage
Trachea

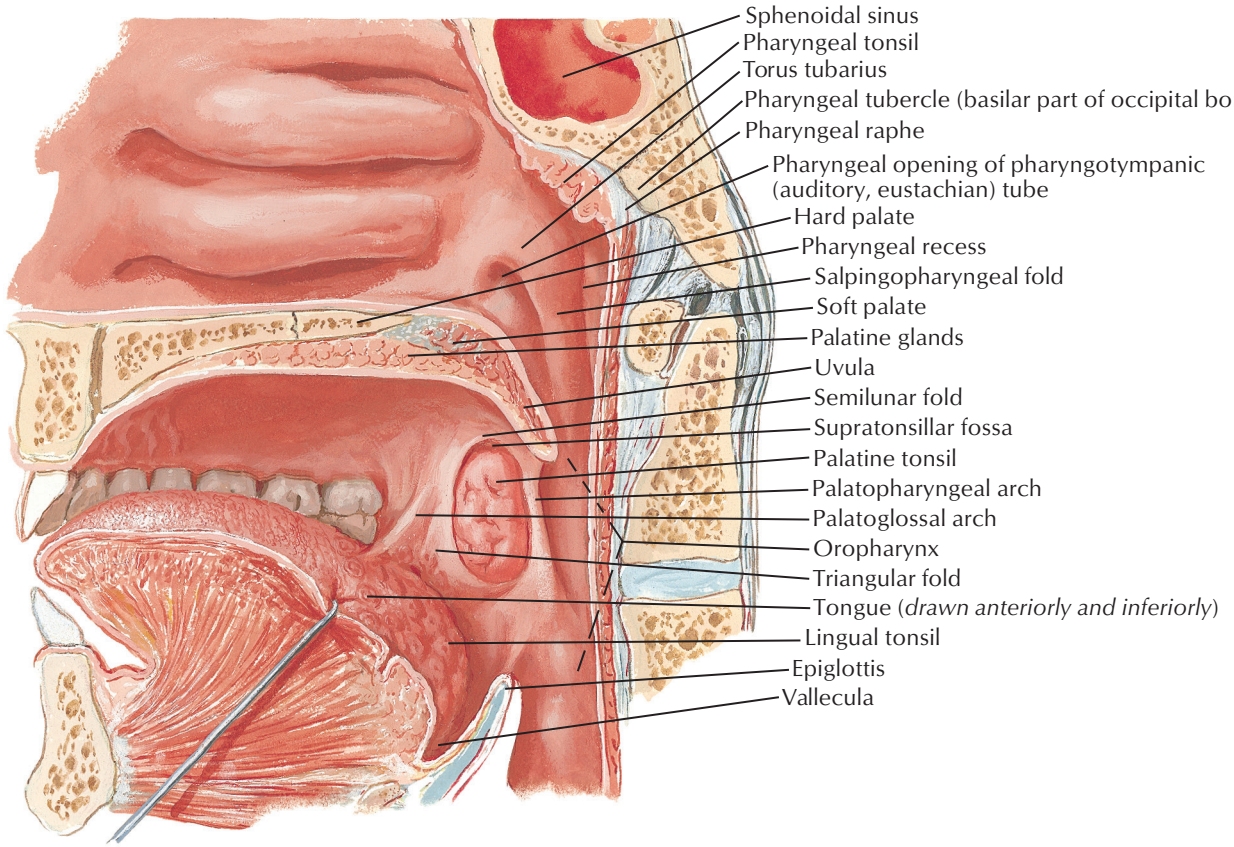

Choanae
Base of skull (basilar part of occipital bone)
Pharyngeal tonsil
Styloid process
Nasal septum
Torus tubarius
Pharyngeal opening of pharyngotympanic (auditory, eustachian) tube
Pharyngeal recess
Parotid gland
Torus levatorius (fold caused by levator veli palatini muscle)
Inferior nasal concha
Salpingopharyngeal fold
Soft palate
Angle of mandible
Submandibular gland
Uvula
Palatine tonsil
Root of tongue
Palatopharyngeal arch
Prominence caused by greater horn of hyoid bone
Epiglottis
Laryngeal inlet (aditus)
Prominence caused by superior horn of thyroid cartilage
Aryepiglottic fold
Piriform fossa (recess)
Cuneiform tubercle
Fold over internal branch of superior laryngeal nerve
Corniculate tubercle
Interarytenoid notch
Prominence over lamina of cricoid cartilage
Trachea
Nasopharynx
Oropharynx
Laryngopharynx
Esophagus

Muscles of Pharynx: Partially Opened Posterior View

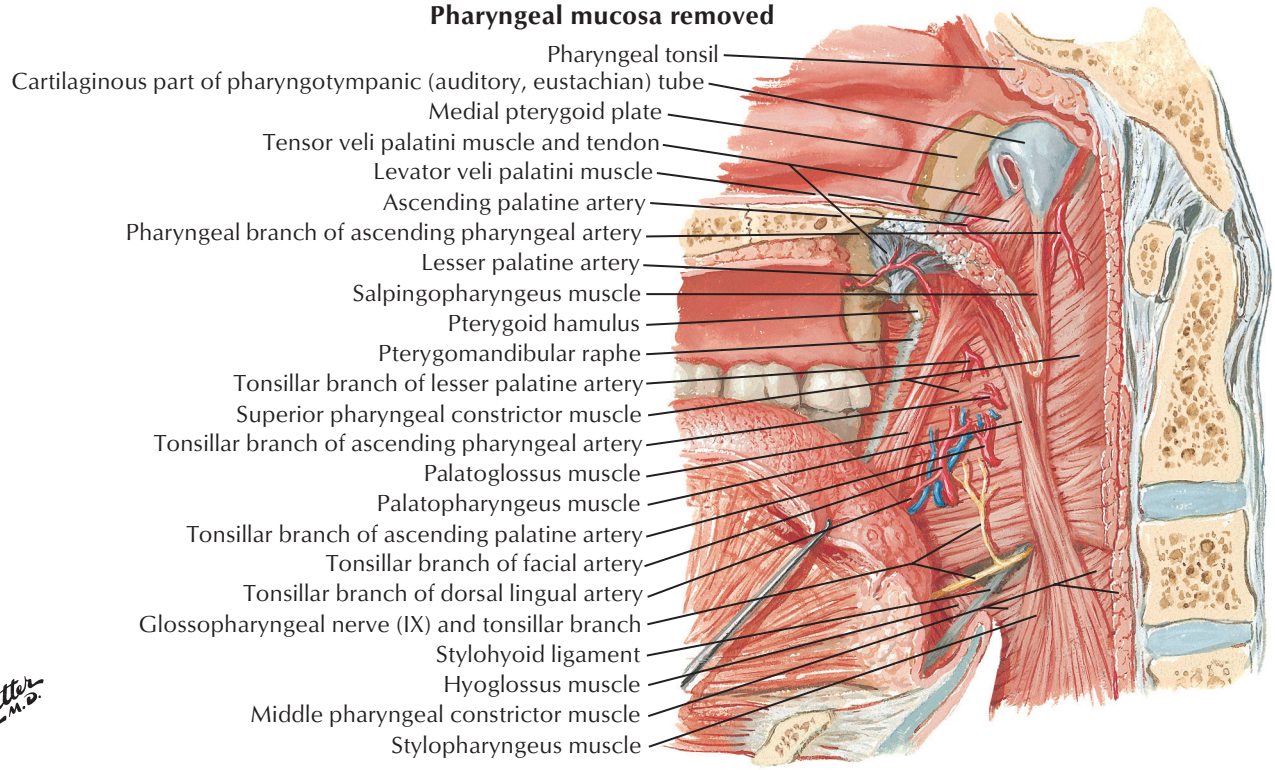
See also Plate 70

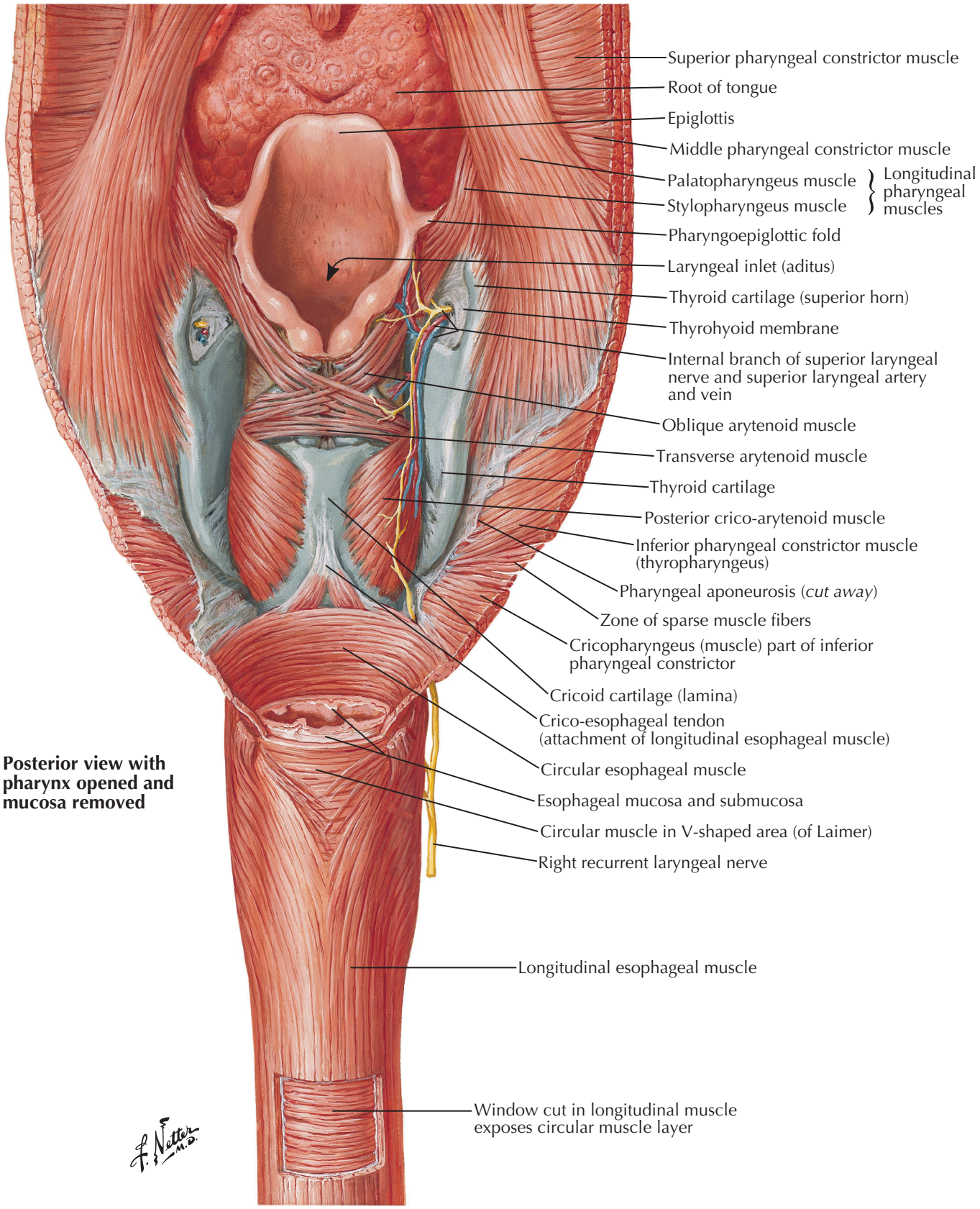


Medial view
sagittal section



Pharyngeal mucosa removed

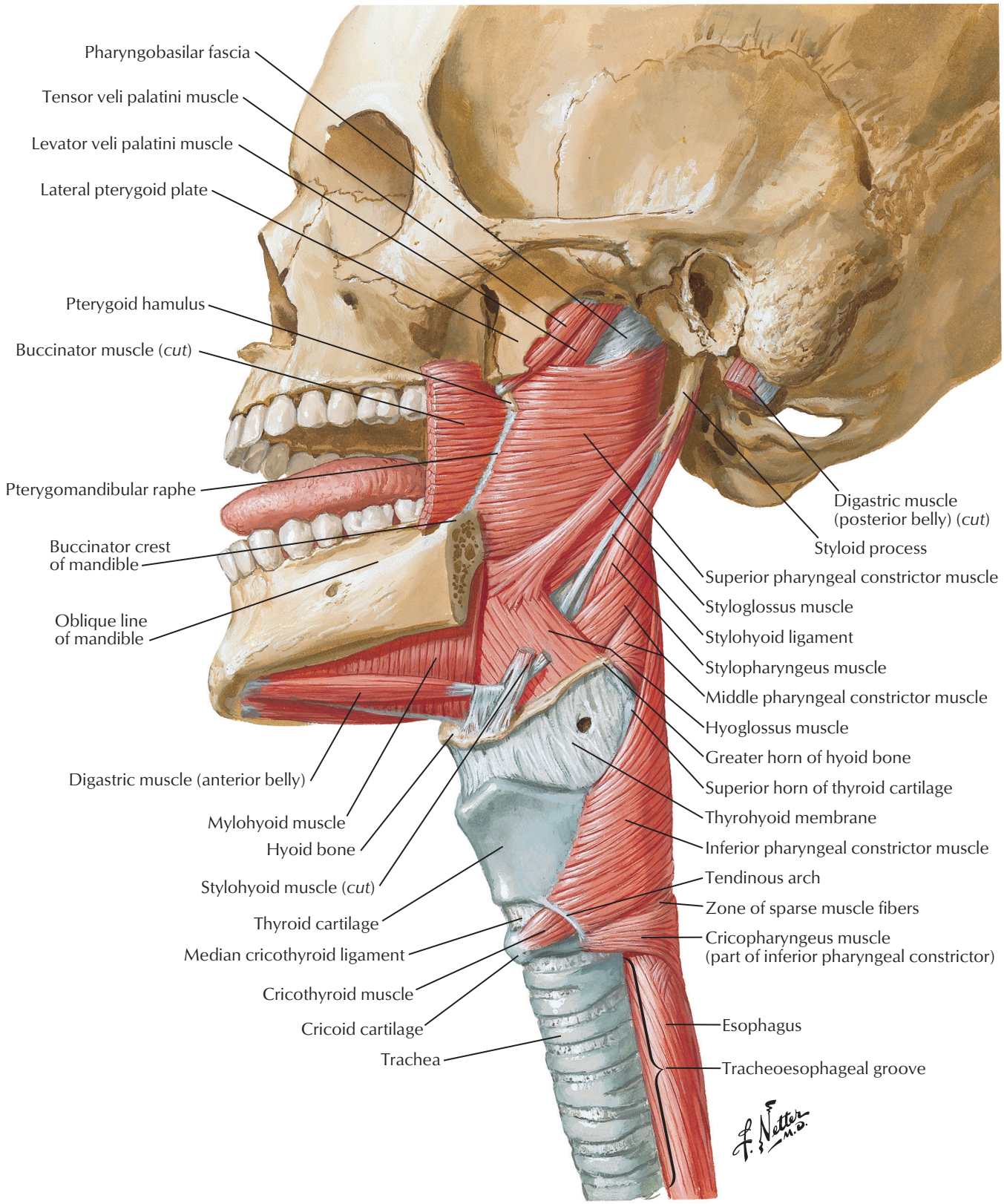


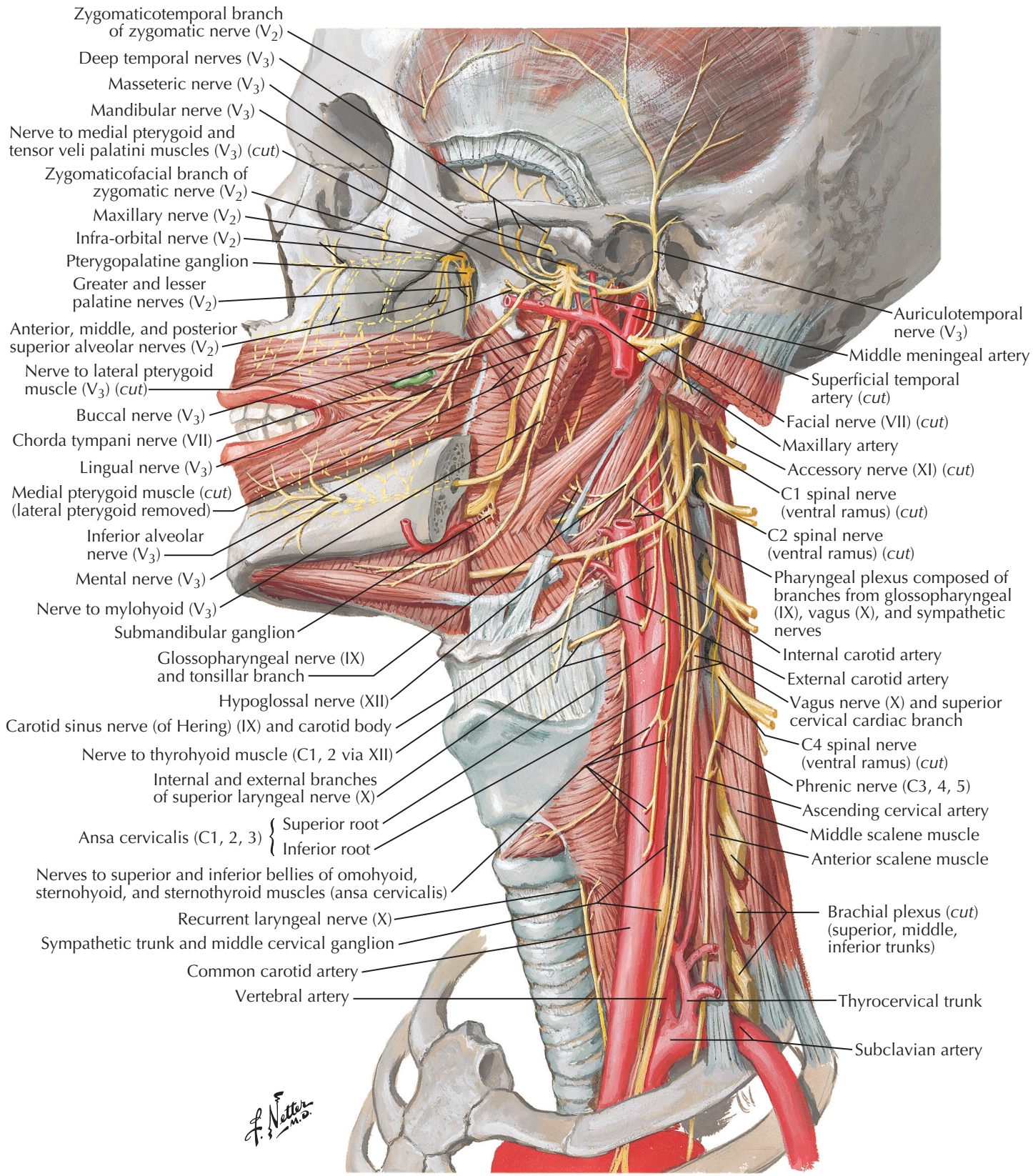


Posterior view with pharynx opened and mucosa removed

Muscles of Pharynx: Lateral View

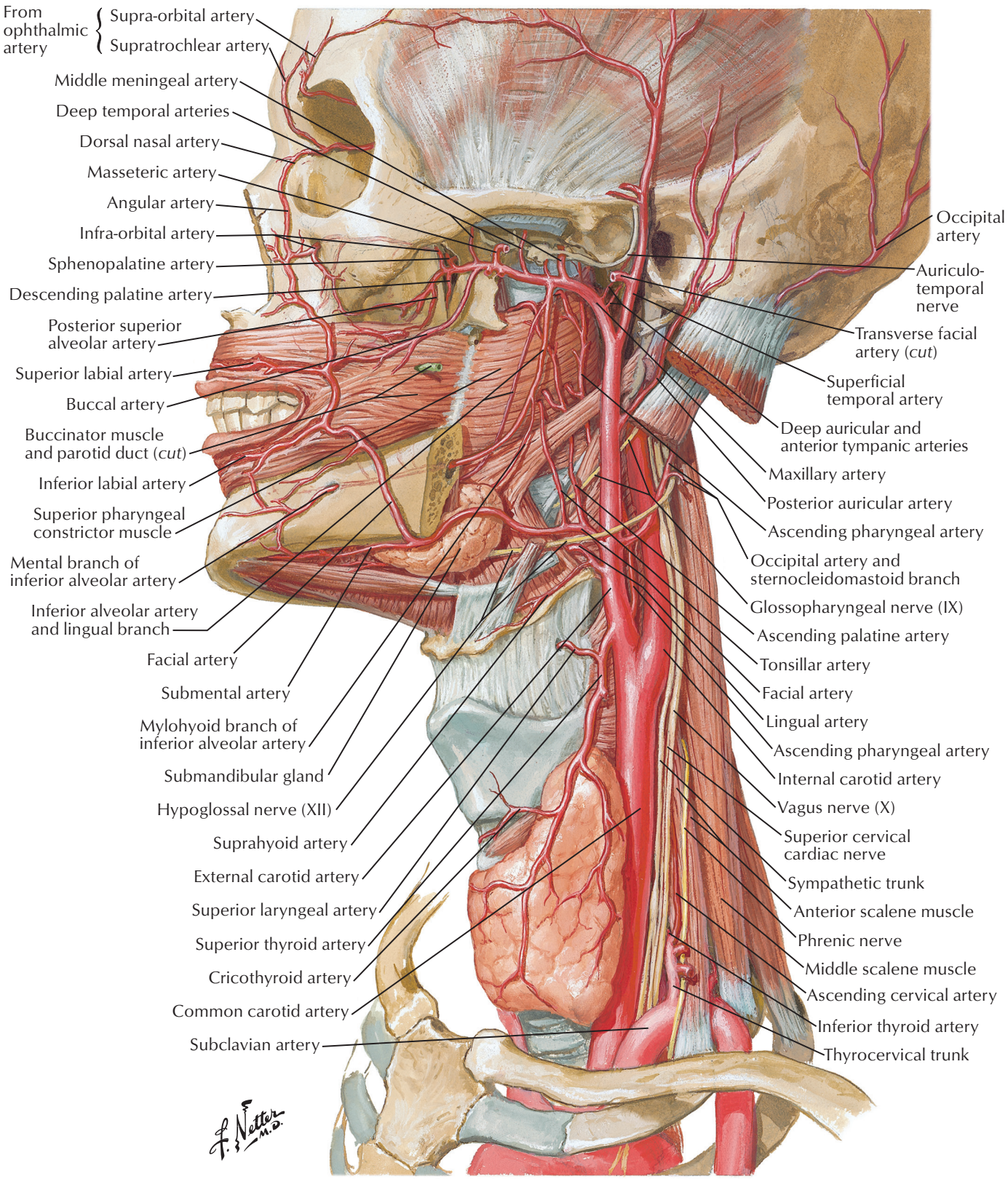
See also Plate 67

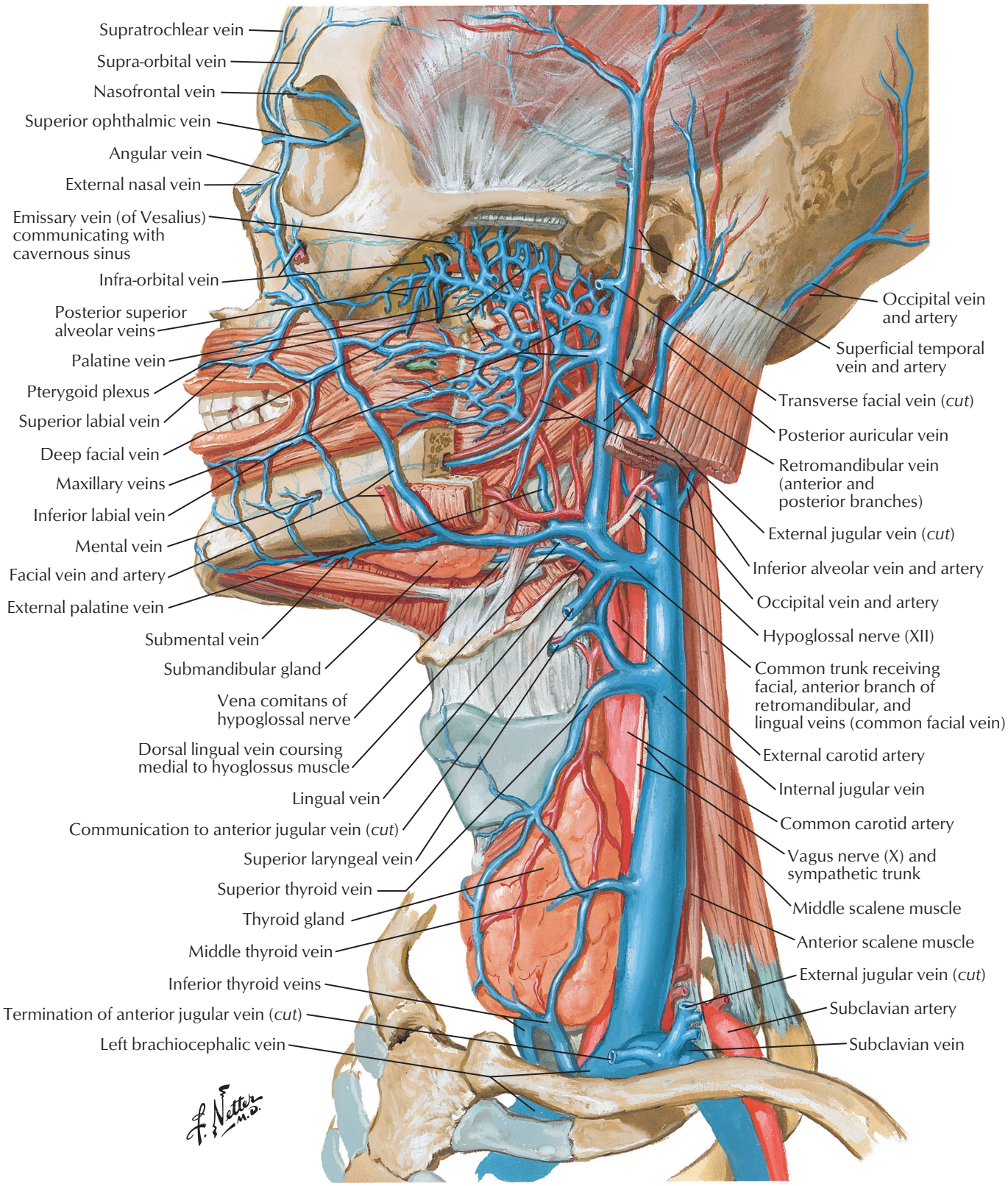



Zygomaticotemporal branch of zygomatic nerve (V_2)
Deep temporal nerves (V_3)
Masseteric nerve (V_3)
Mandibular nerve (V_3)
Nerve to medial pterygoid and tensor veli palatini muscles (V_3) (*cut*)
Zygomaticofacial branch of zygomatic nerve (V_2)
Maxillary nerve (V_2)
Infra-orbital nerve (V_2)
Pterygopalatine ganglion
Greater and lesser palatine nerves (V_2)
Anterior, middle, and posterior superior alveolar nerves (V_2)
Nerve to lateral pterygoid muscle (V_3) (*cut*)
Buccal nerve (V_3)
Chorda tympani nerve (VII)
Lingual nerve (V_3)
Medial pterygoid muscle (*cut*) (lateral pterygoid removed)
Inferior alveolar nerve (V_3)
Mental nerve (V_3)
Nerve to mylohyoid (V_3)
Submandibular ganglion
Glossopharyngeal nerve (IX) and tonsillar branch
Hypoglossal nerve (XII)
Carotid sinus nerve (of Hering) (IX) and carotid body
Nerve to thyrohyoid muscle (C1, 2 via XII)
Internal and external branches of superior laryngeal nerve (X)
Ansa cervicalis (C1, 2, 3)
Superior root
Inferior root
Nerves to superior and inferior bellies of omohyoid, sternohyoid, and sternothyroid muscles (ansa cervicalis)
Recurrent laryngeal nerve (X)
Sympathetic trunk and middle cervical ganglion
Common carotid artery
Vertebral artery
Auriculotemporal nerve (V_3)
Middle meningeal artery
Superficial temporal artery (*cut*)
Facial nerve (VII) (*cut*)
Maxillary artery
Accessory nerve (XI) (*cut*)
C1 spinal nerve (ventral ramus) (*cut*)
C2 spinal nerve (ventral ramus) (*cut*)
Pharyngeal plexus composed of branches from glossopharyngeal (IX), vagus (X), and sympathetic nerves
Internal carotid artery
External carotid artery
Vagus nerve (X) and superior cervical cardiac branch
C4 spinal nerve (ventral ramus) (*cut*)
Phrenic nerve (C3, 4, 5)
Ascending cervical artery
Middle scalene muscle
Anterior scalene muscle
Brachial plexus (*cut*) (superior, middle, inferior trunks)
Thyrocervical trunk
Subclavian artery
F. Netter M.D.

Arteries of Oral and Pharyngeal Regions

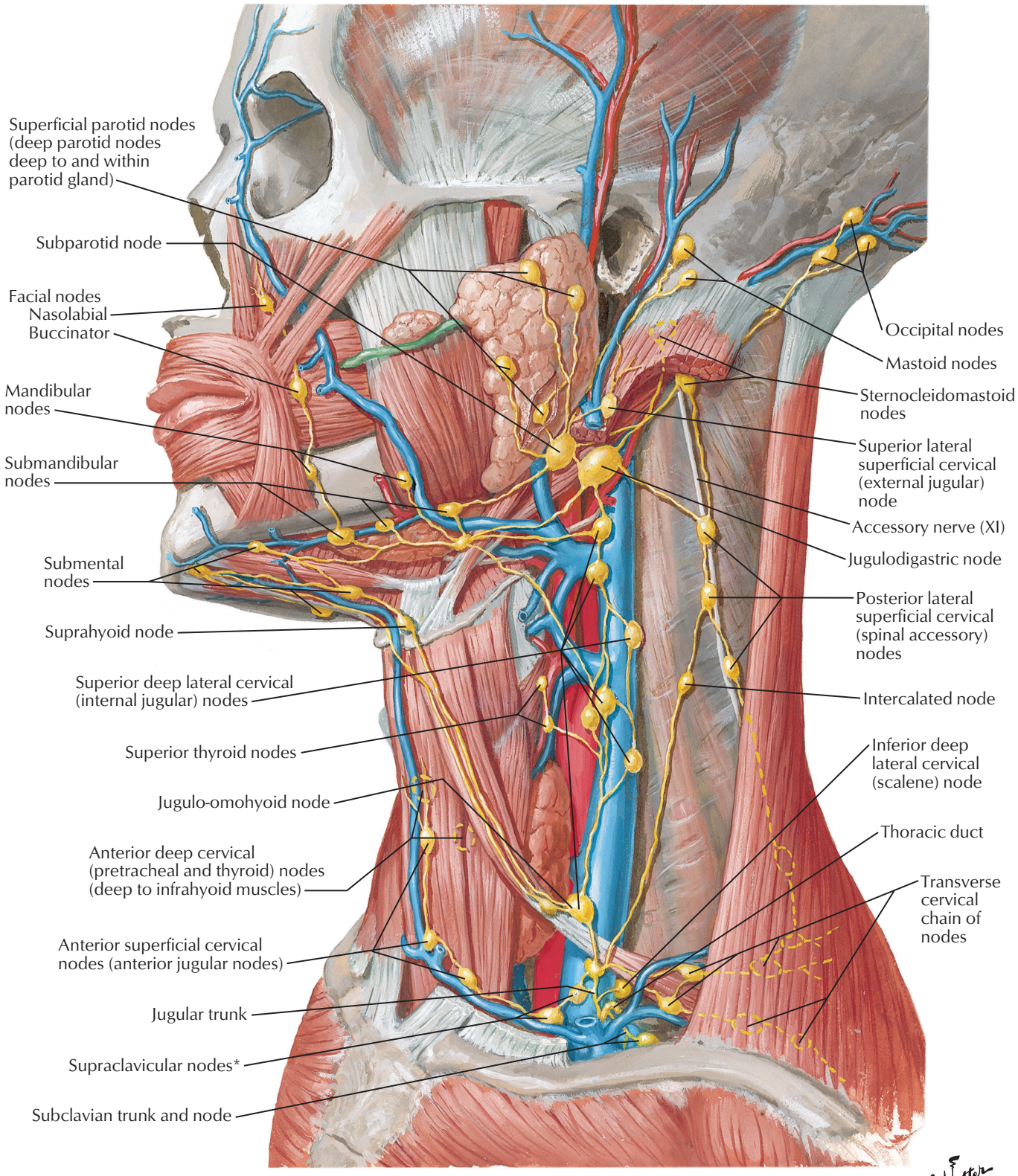
See also Plates 34, 51



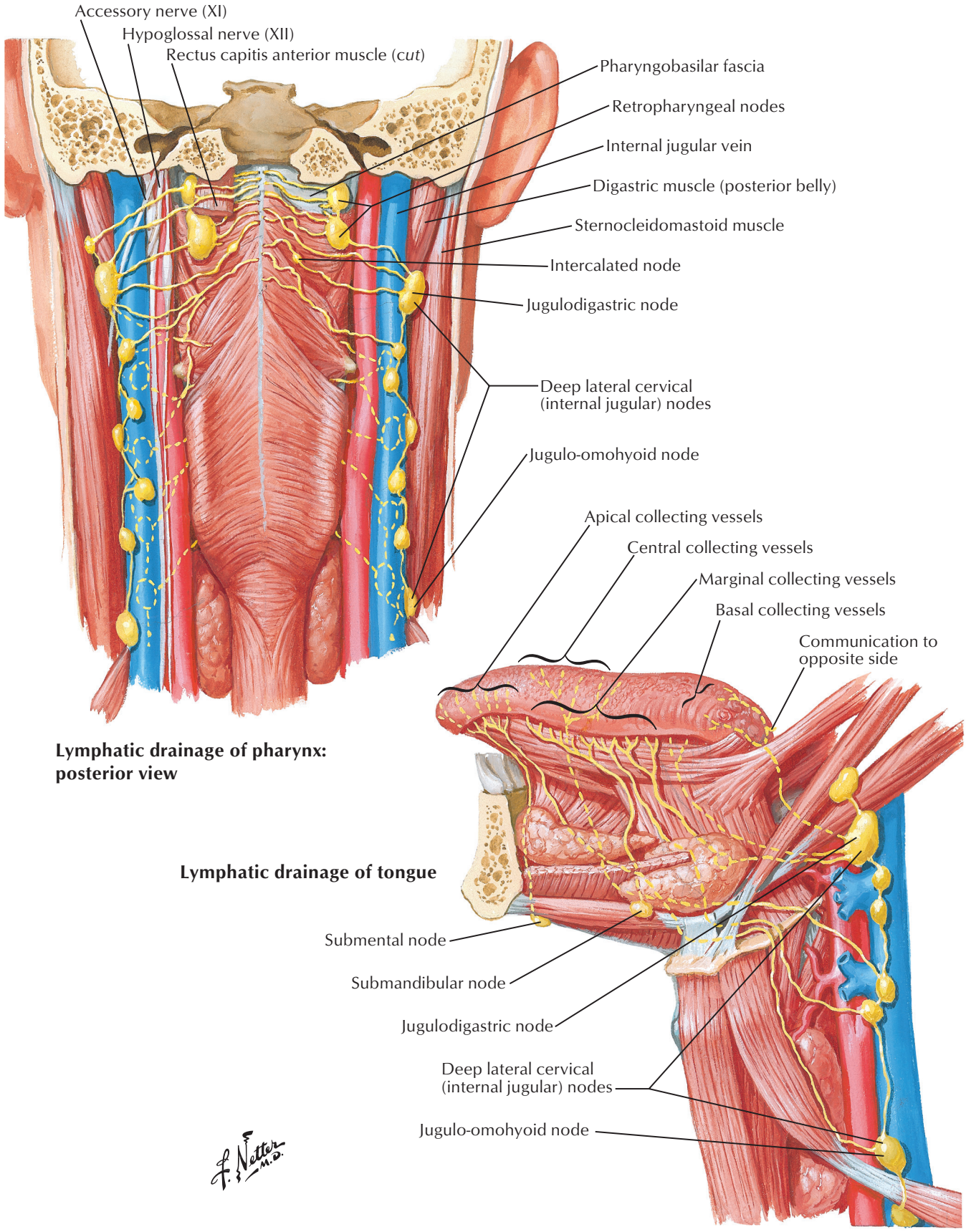

Supratrochlear vein
Supra-orbital vein
Nasofrontal vein
Superior ophthalmic vein
Angular vein
External nasal vein
Emissary vein (of Vesalius) communicating with cavernous sinus
Infra-orbital vein
Posterior superior alveolar veins
Palatine vein
Pterygoid plexus
Superior labial vein
Deep facial vein
Maxillary veins
Inferior labial vein
Mental vein
Facial vein and artery
External palatine vein
Submental vein
Submandibular gland
Vena comitans of hypoglossal nerve
Dorsal lingual vein coursing medial to hyoglossus muscle
Lingual vein
Communication to anterior jugular vein (cut)
Superior laryngeal vein
Superior thyroid vein
Thyroid gland
Middle thyroid vein
Inferior thyroid veins
Termination of anterior jugular vein (cut)
Left brachiocephalic vein
Occipital vein and artery
Superficial temporal vein and artery
Transverse facial vein (cut)
Posterior auricular vein
Retromandibular vein (anterior and posterior branches)
External jugular vein (cut)
Inferior alveolar vein and artery
Occipital vein and artery
Hypoglossal nerve (XII)
Common trunk receiving facial, anterior branch of retromandibular, and lingual veins (common facial vein)
External carotid artery
Internal jugular vein
Common carotid artery
Vagus nerve (X) and sympathetic trunk
Middle scalene muscle
Anterior scalene muscle
External jugular vein (cut)
Subclavian artery
Subclavian vein
F. Netter M.D.

Lymph Vessels and Nodes of Head and Neck

See also Plates 73, 105



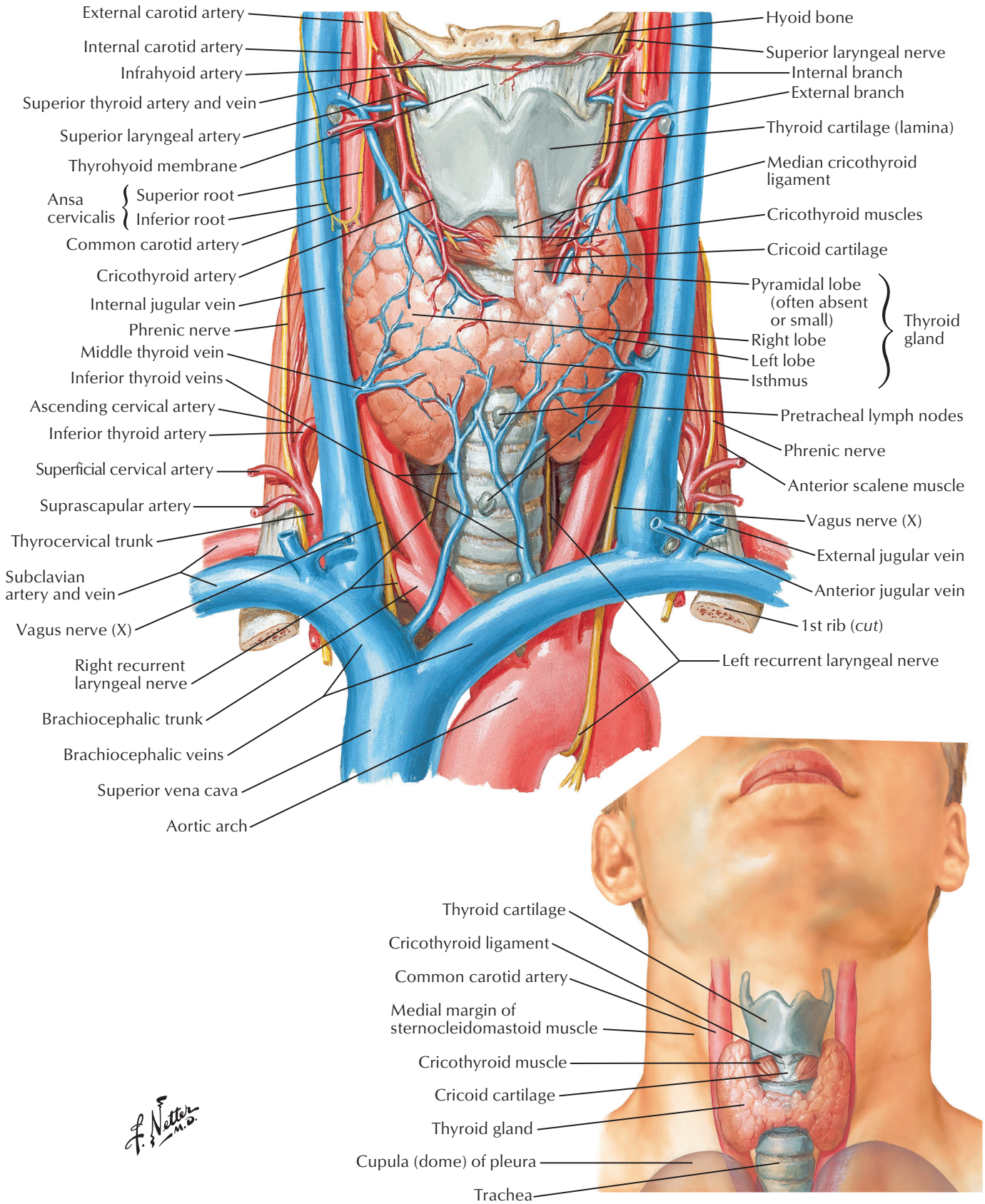
**The supraclavicular group of nodes (also known as the lower deep cervical group), especially on the left, are also sometimes referred to as the signal or sentinel lymph nodes of Virchow or Troisier, especially when sufficiently enlarged and palpable. These nodes (or a single node) are so termed because they may be the first recognized presumptive evidence of malignant disease in the viscera.*



Lymphatic drainage of pharynx: posterior view

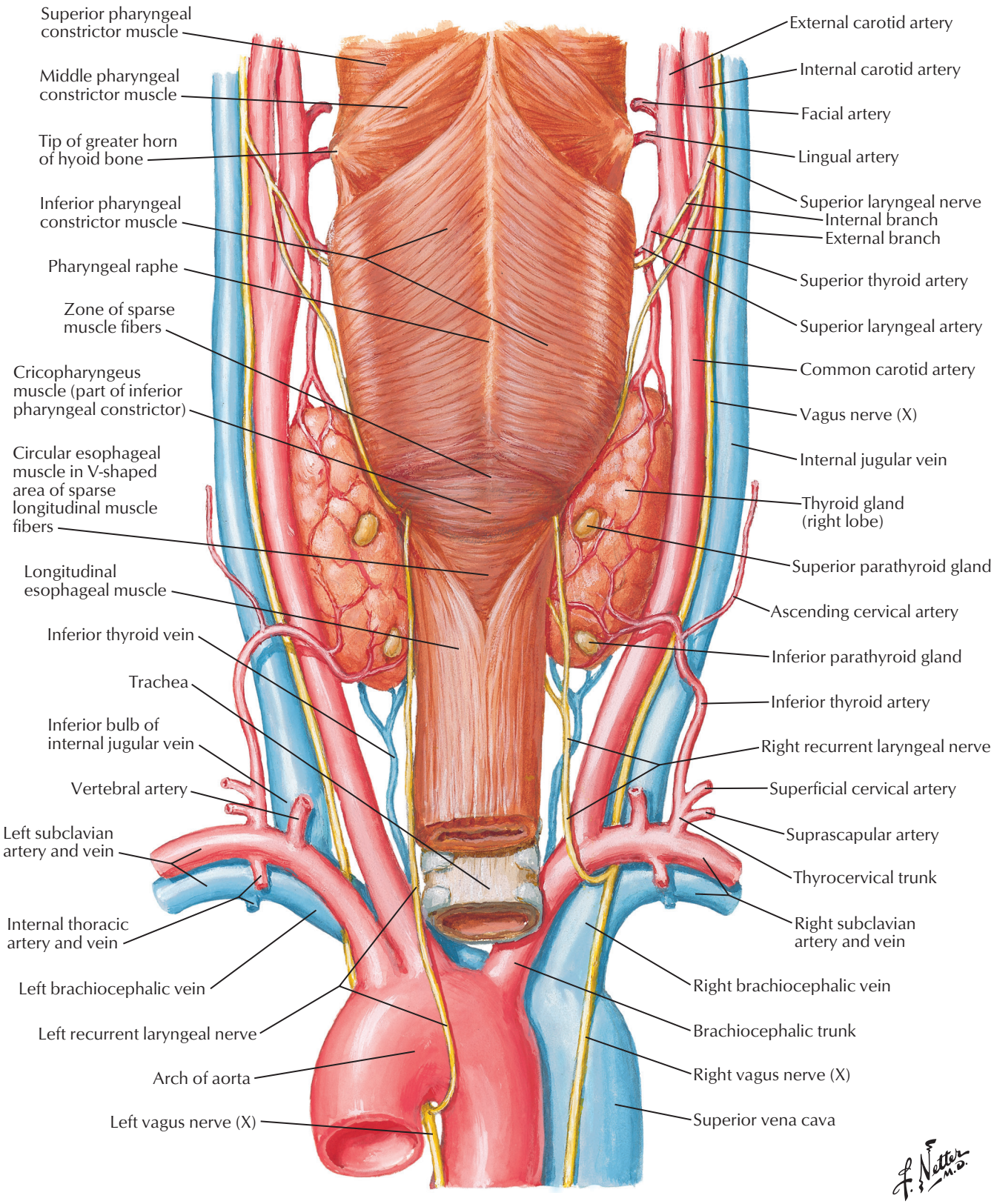
Lymphatic drainage of tongue

Thyroid Gland: Anterior View



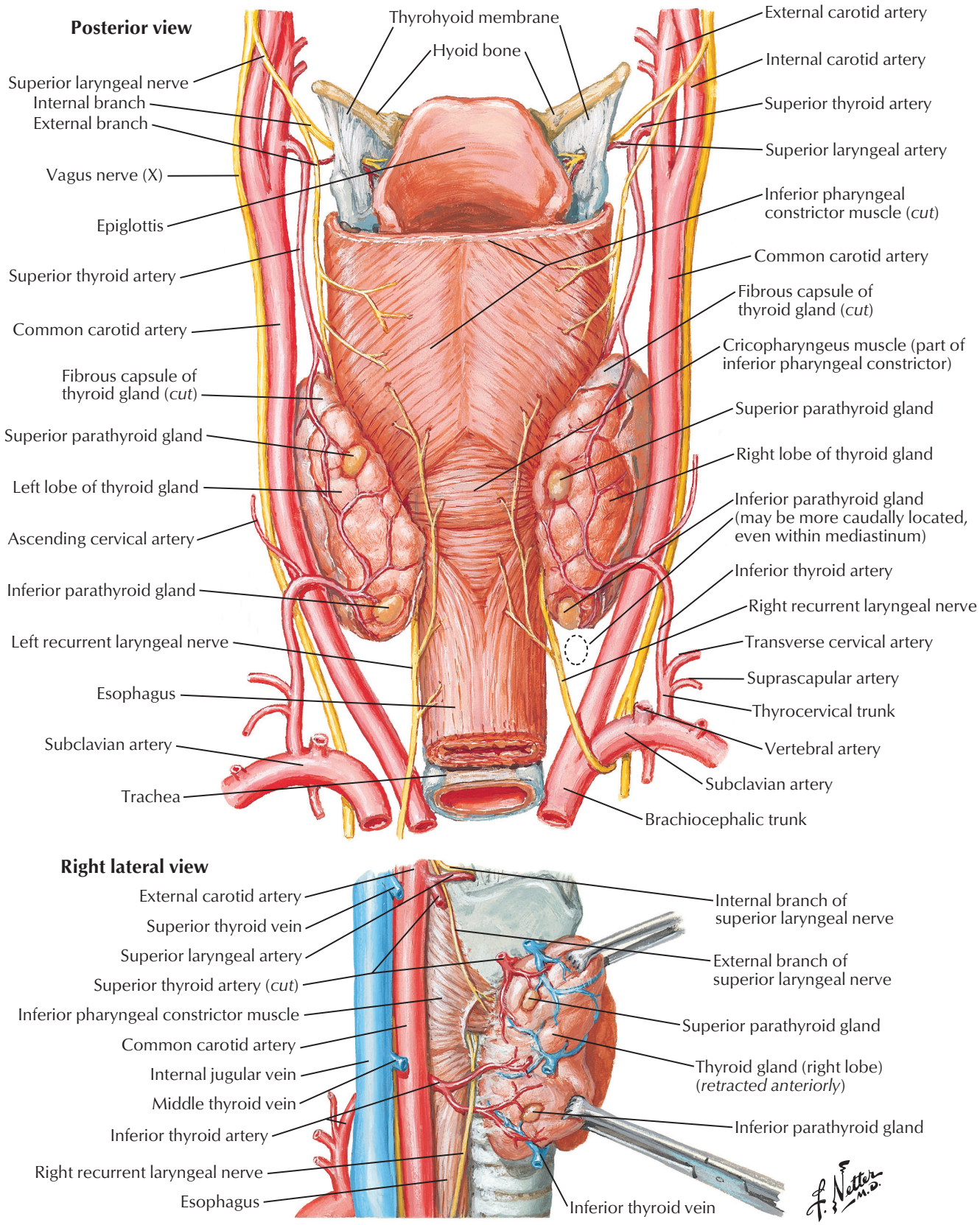
Thyroid Gland and Pharynx: Posterior View

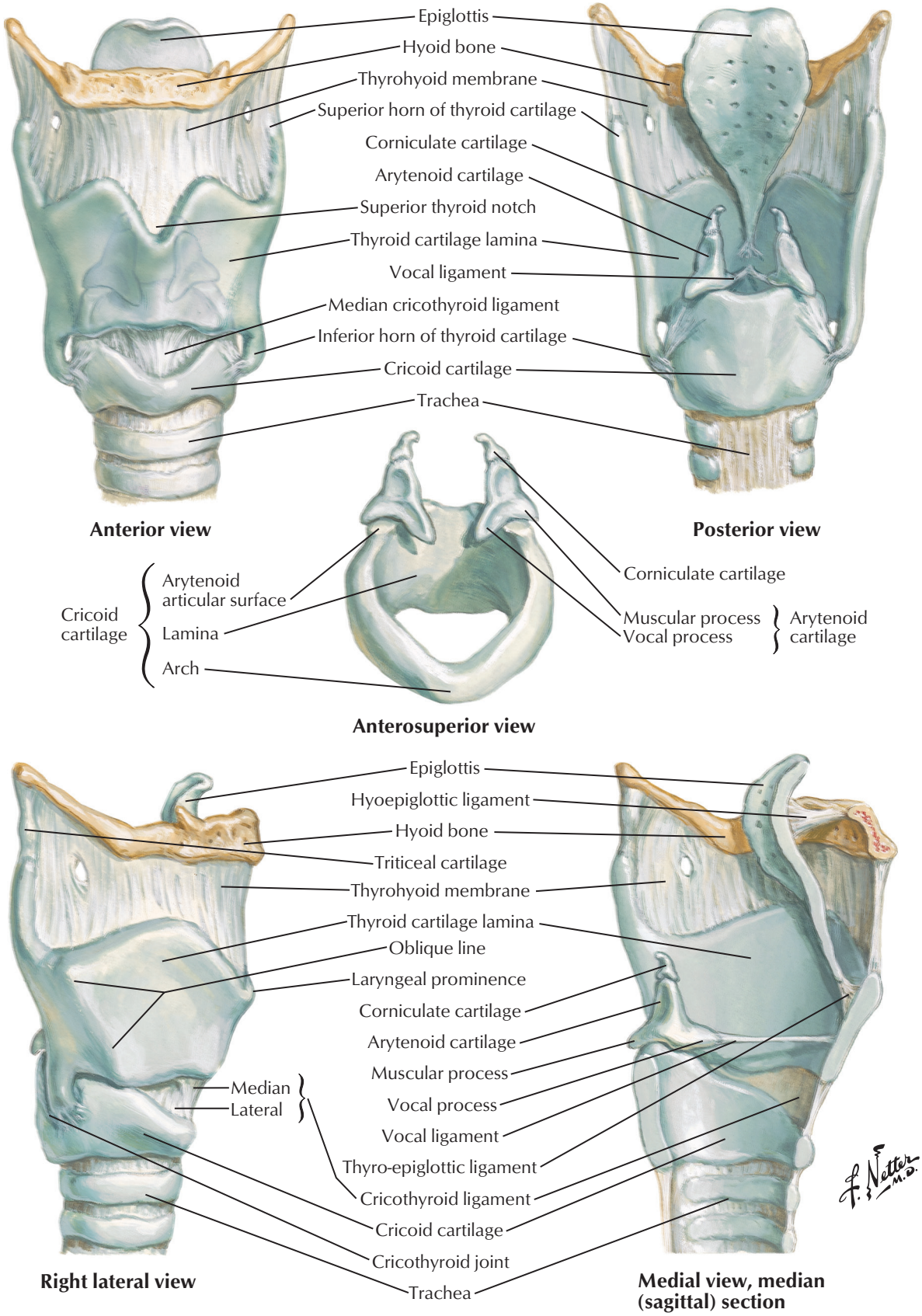
See also Plate 78



Parathyroid Glands

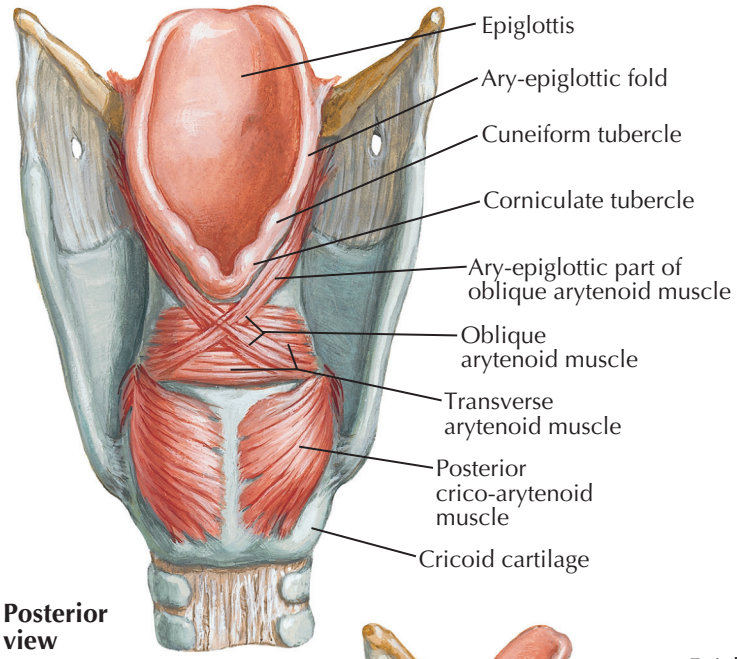
See also Plates 69, 77, 82



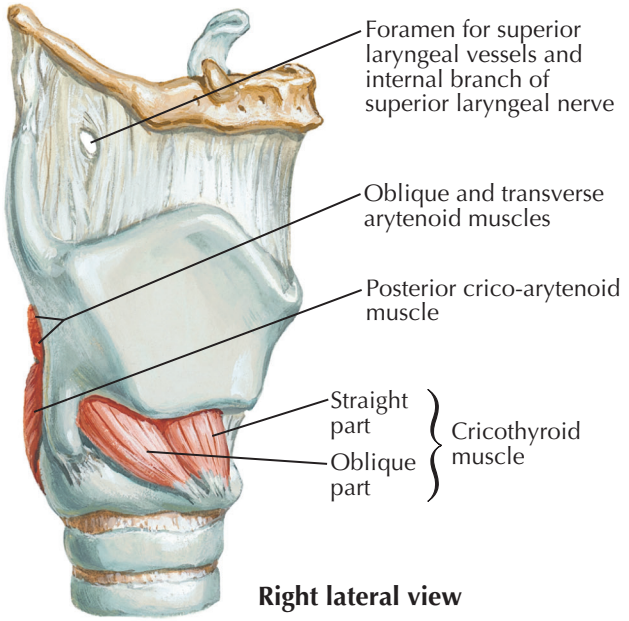

Epiglottis
Hyoid bone
Thyrohyoid membrane
Superior horn of thyroid cartilage
Corniculate cartilage
Arytenoid cartilage
Superior thyroid notch
Thyroid cartilage lamina
Vocal ligament
Median cricothyroid ligament
Inferior horn of thyroid cartilage
Cricoid cartilage
Trachea
Anterior view
Posterior view
Cricoid cartilage
Arytenoid articular surface
Lamina
Arch
Corniculate cartilage
Muscular process
Vocal process
Arytenoid cartilage
Anterosuperior view
Epiglottis
Hyoepiglottic ligament
Hyoid bone
Triticeal cartilage
Thyrohyoid membrane
Thyroid cartilage lamina
Oblique line
Laryngeal prominence
Corniculate cartilage
Arytenoid cartilage
Muscular process
Vocal process
Vocal ligament
Thyro-epiglottic ligament
Cricothyroid ligament
Cricoid cartilage
Cricothyroid joint
Trachea
Median
Lateral
Right lateral view
Medial view, median (sagittal) section

Intrinsic Muscles of Larynx

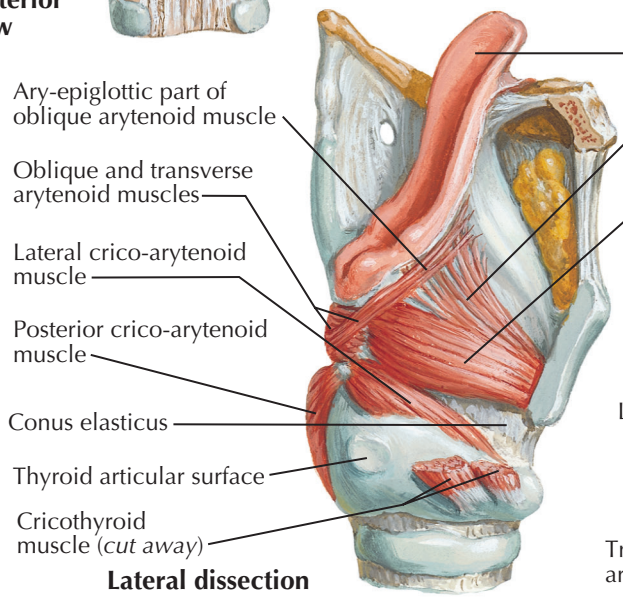
See also Plates 79, 81, 82



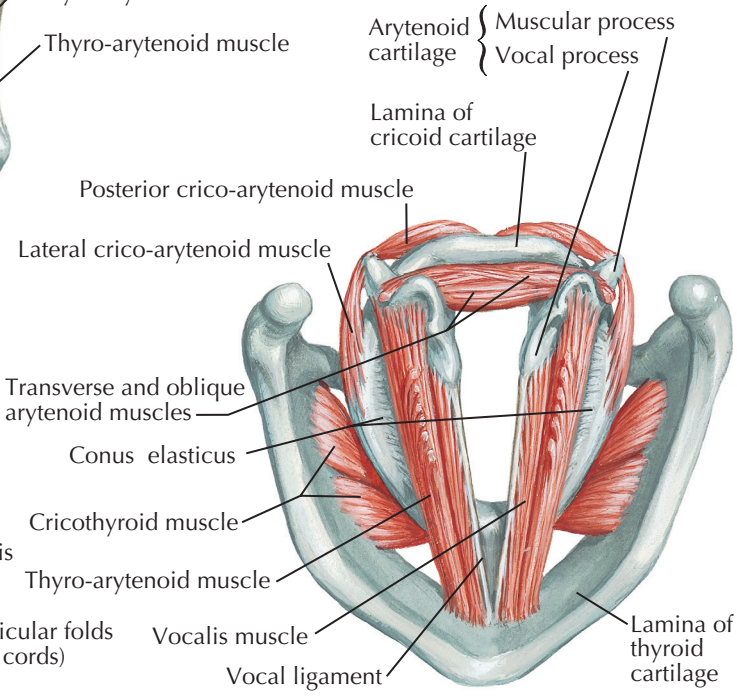
Posterior view



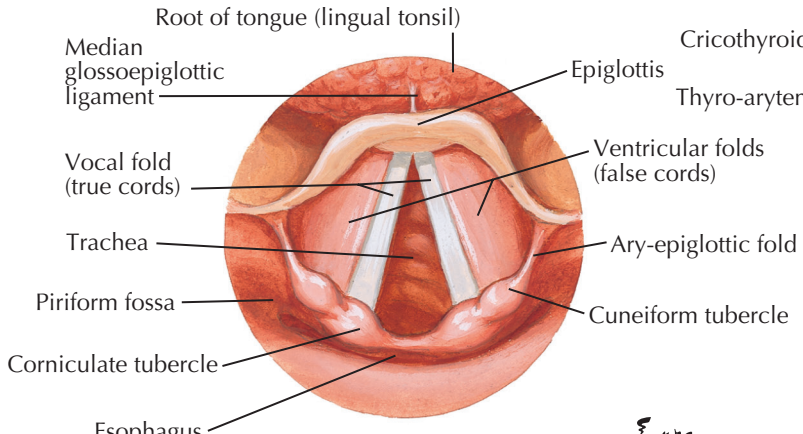
Right lateral view



Lateral dissection



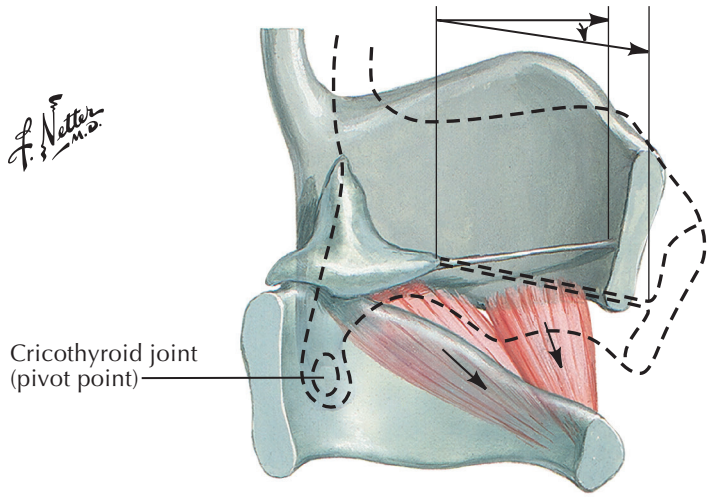
Superior view



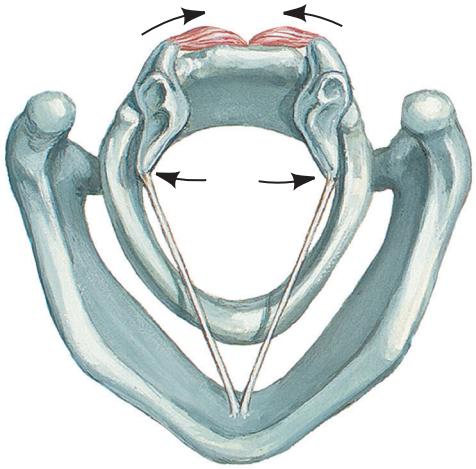
Normal larynx: inspiration

Action of Intrinsic Muscles of Larynx

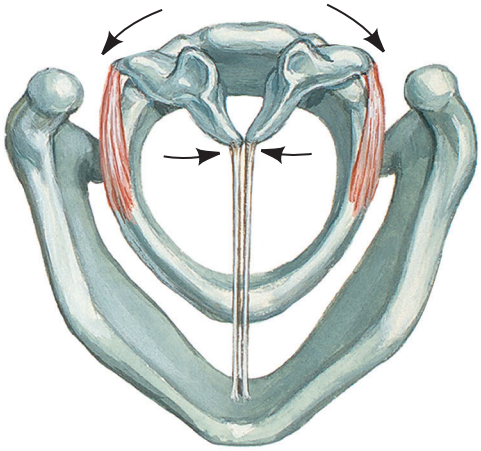
See also Plates 79, 80, 82



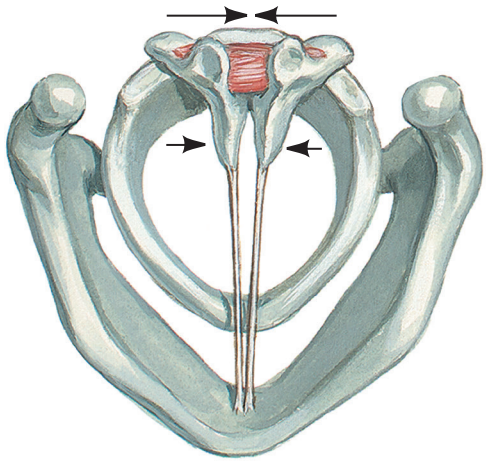
Action of cricothyroid muscles
Lengthening (increasing tension) of vocal ligaments



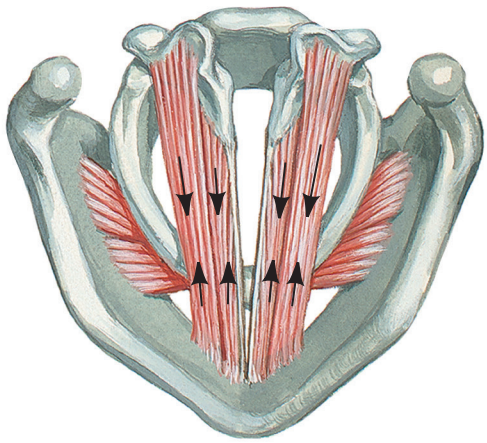
Action of posterior crico-arytenoid muscles
Abduction of vocal ligaments



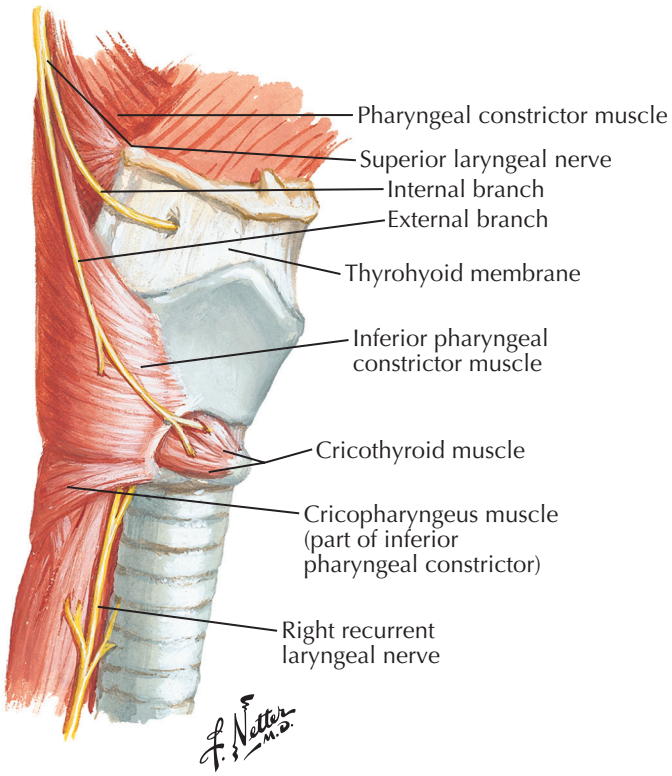
Action of lateral crico-arytenoid muscles
Adduction of vocal ligaments

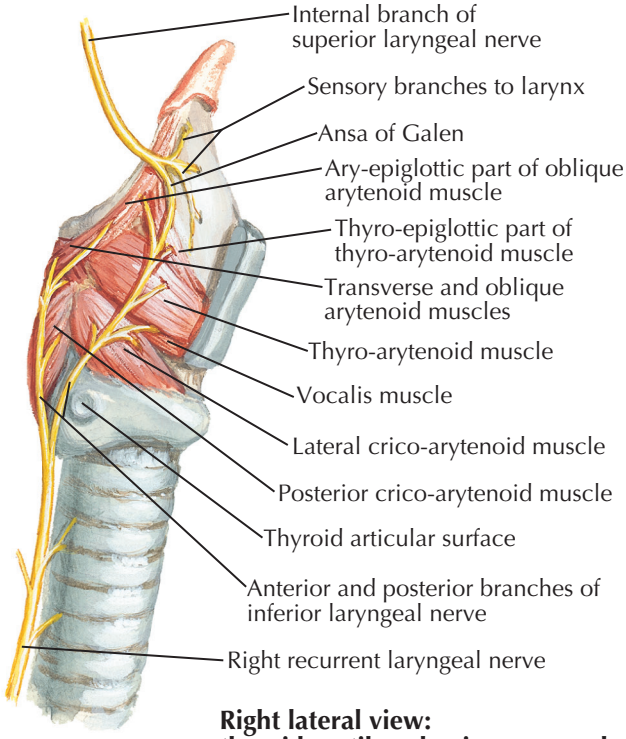


Action of transverse and oblique arytenoid muscles
Adduction of vocal ligaments



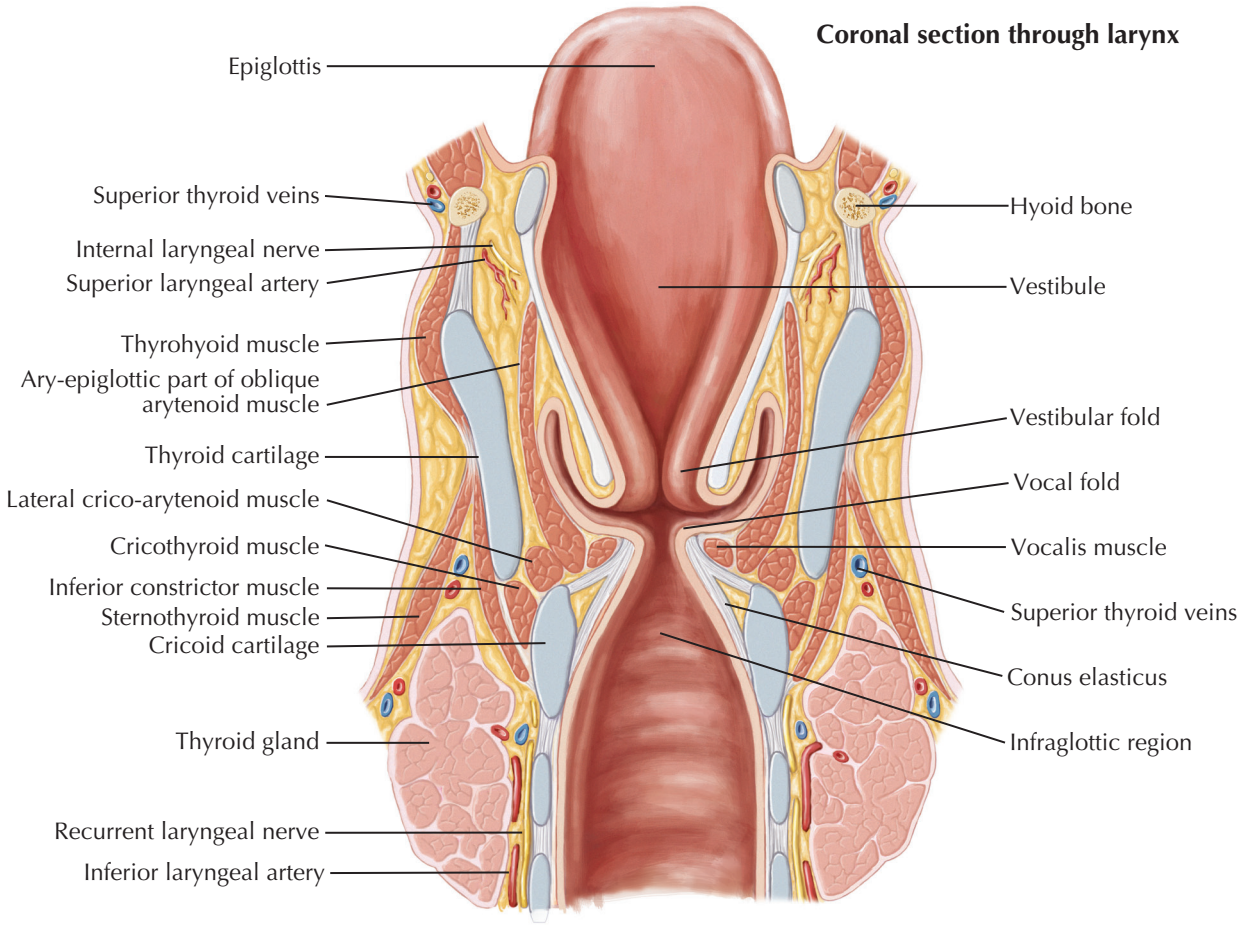
Action of vocalis and thyro-arytenoid muscles
Shortening (relaxation) of vocal ligaments

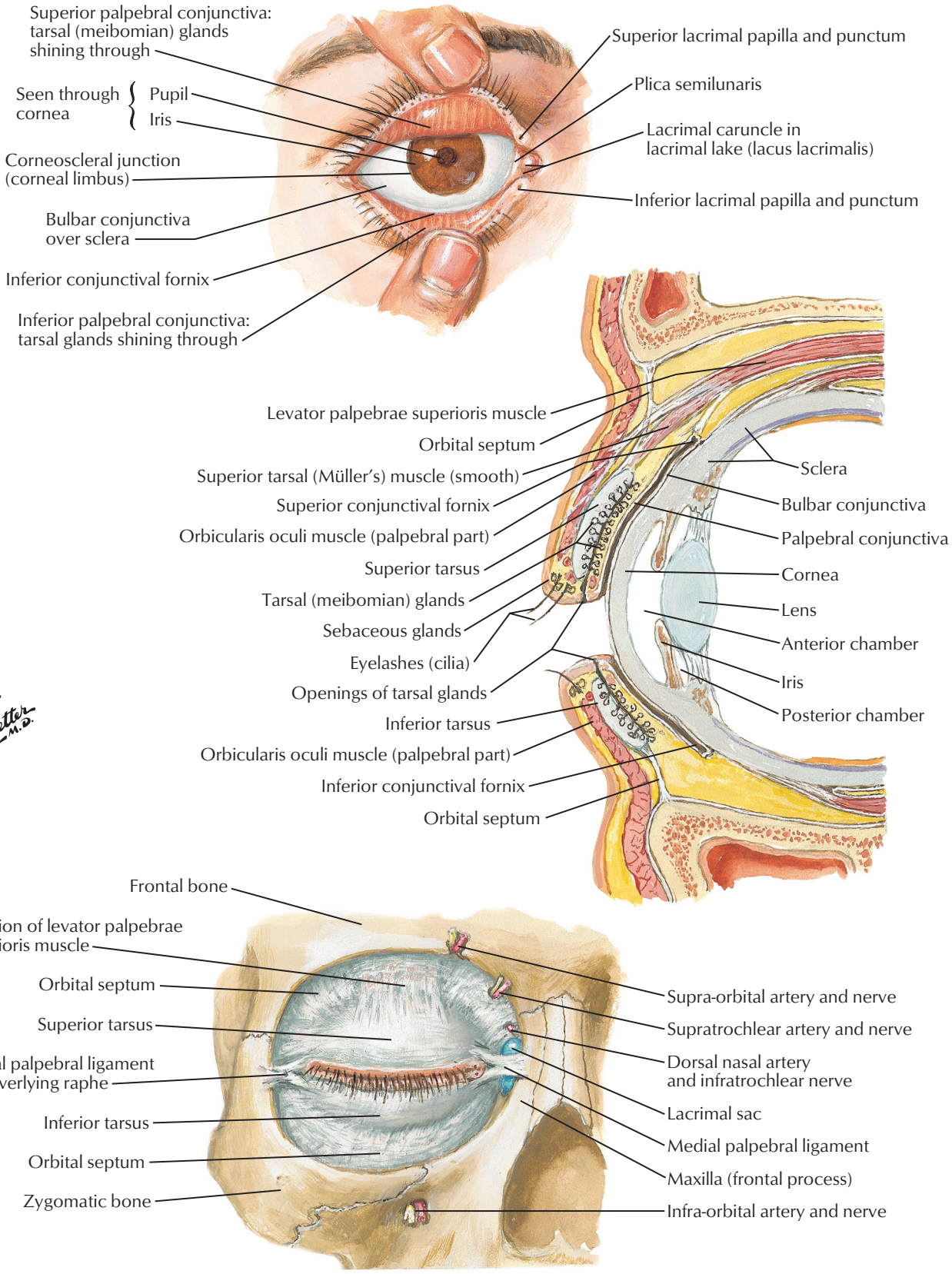




Right lateral view: thyroid cartilage lamina removed

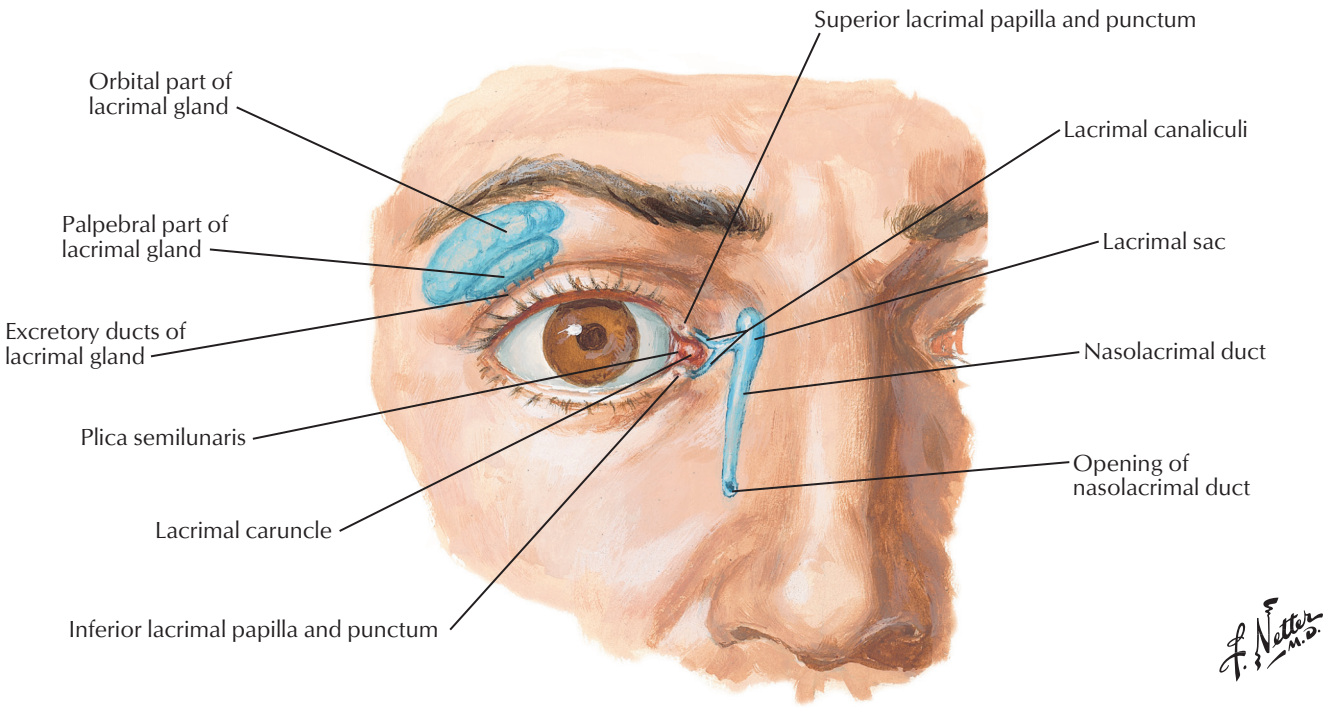
Coronal section through larynx

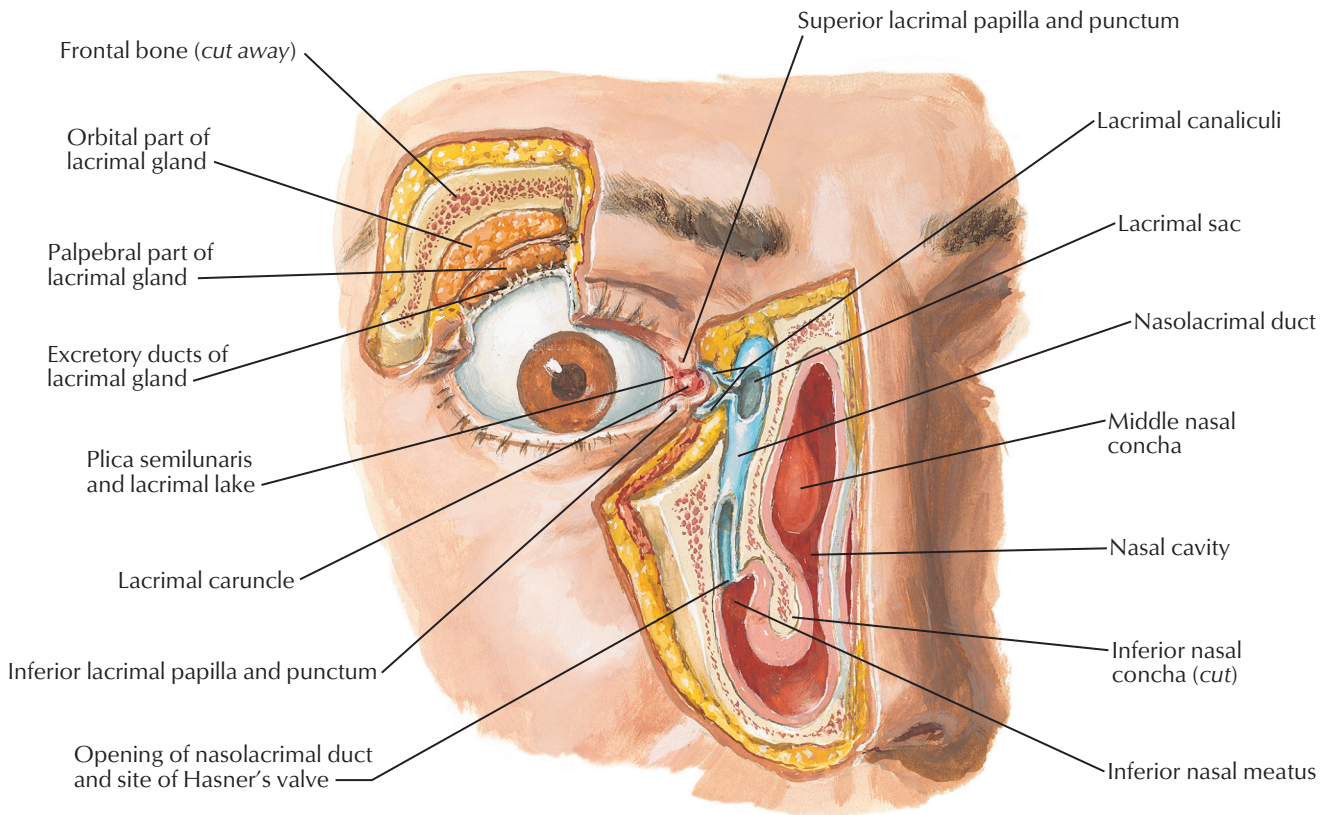



Superior palpebral conjunctiva: tarsal (meibomian) glands shining through
Seen through cornea
Pupil
Iris
Corneoscleral junction (corneal limbus)
Bulbar conjunctiva over sclera
Inferior conjunctival fornix
Inferior palpebral conjunctiva: tarsal glands shining through
Superior lacrimal papilla and punctum
Plica semilunaris
Lacrimal caruncle in lacrimal lake (lacus lacrimalis)
Inferior lacrimal papilla and punctum
Levator palpebrae superioris muscle
Orbital septum
Superior tarsal (Müller's) muscle (smooth)
Superior conjunctival fornix
Orbicularis oculi muscle (palpebral part)
Superior tarsus
Tarsal (meibomian) glands
Sebaceous glands
Eyelashes (cilia)
Openings of tarsal glands
Inferior tarsus
Orbicularis oculi muscle (palpebral part)
Inferior conjunctival fornix
Orbital septum
Sclera
Bulbar conjunctiva
Palpebral conjunctiva
Cornea
Lens
Anterior chamber
Iris
Posterior chamber
F. Netter M.D.
Frontal bone
Insertion of levator palpebrae superioris muscle
Orbital septum
Superior tarsus
Lateral palpebral ligament and overlying raphe
Inferior tarsus
Orbital septum
Zygomatic bone
Supra-orbital artery and nerve
Supratrochlear artery and nerve
Dorsal nasal artery and infratrochlear nerve
Lacrimal sac
Medial palpebral ligament
Maxilla (frontal process)
Infra-orbital artery and nerve

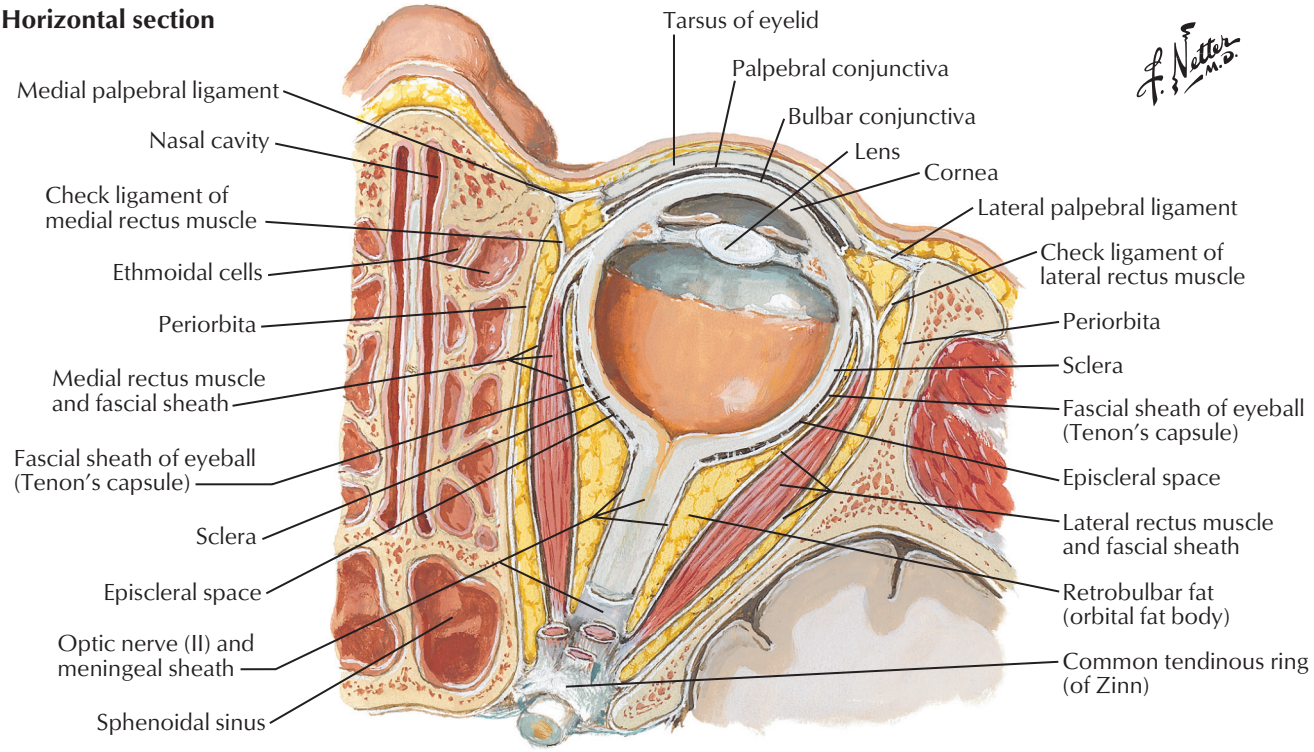
Lacrimal Apparatus

See also **Plate 134**

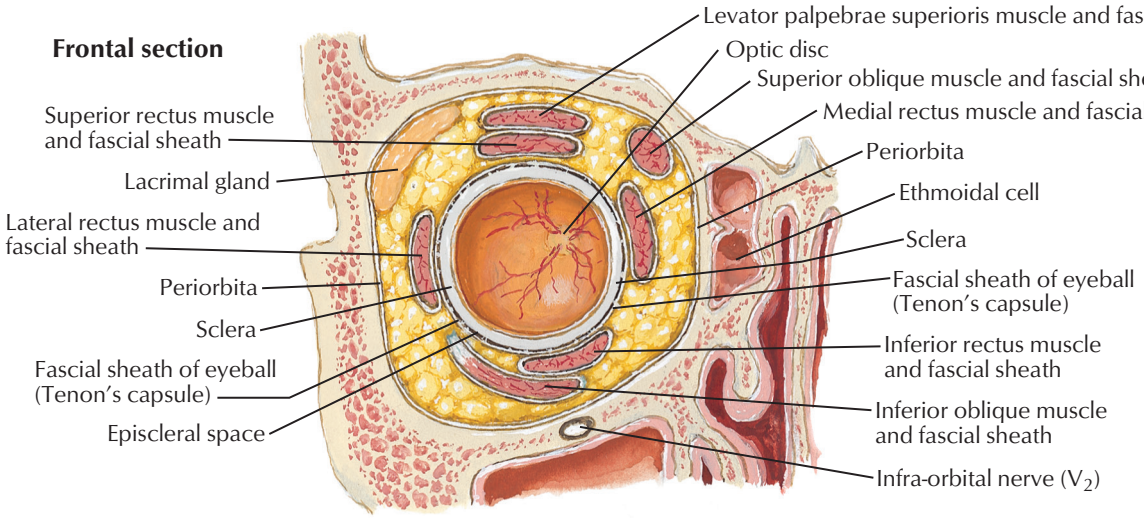




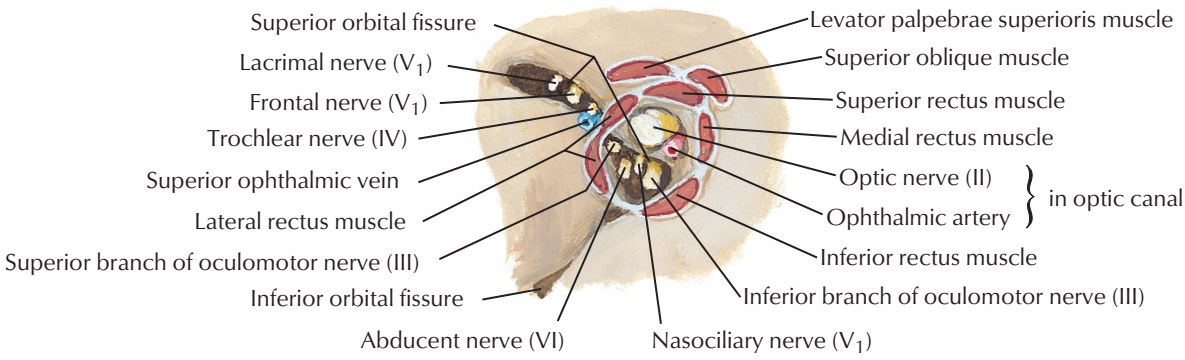
Horizontal section



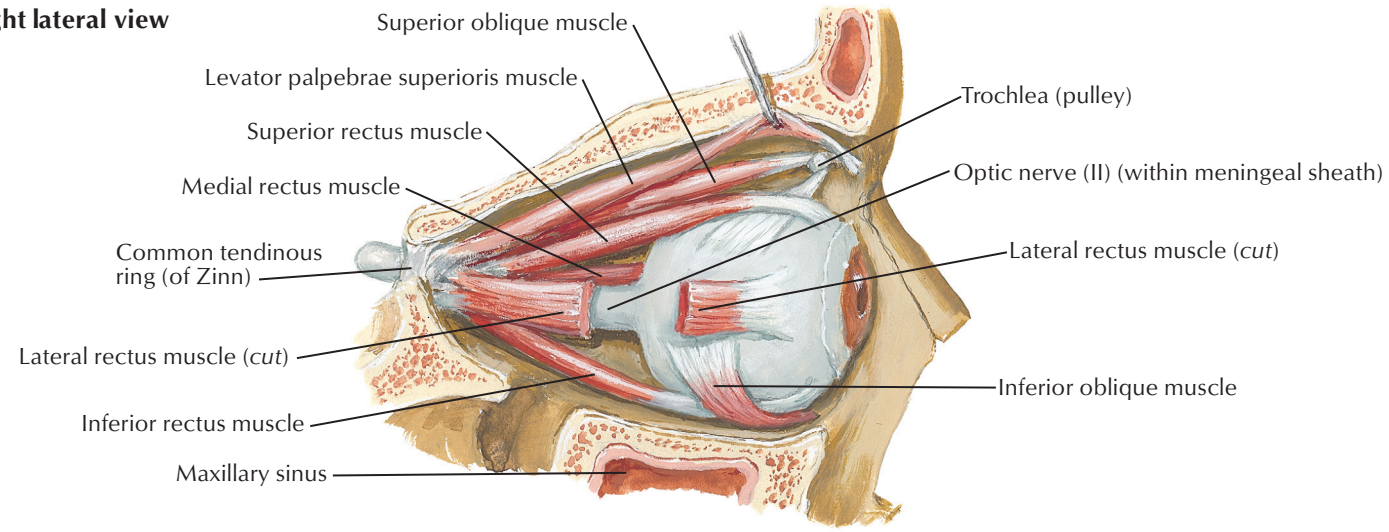
Frontal section



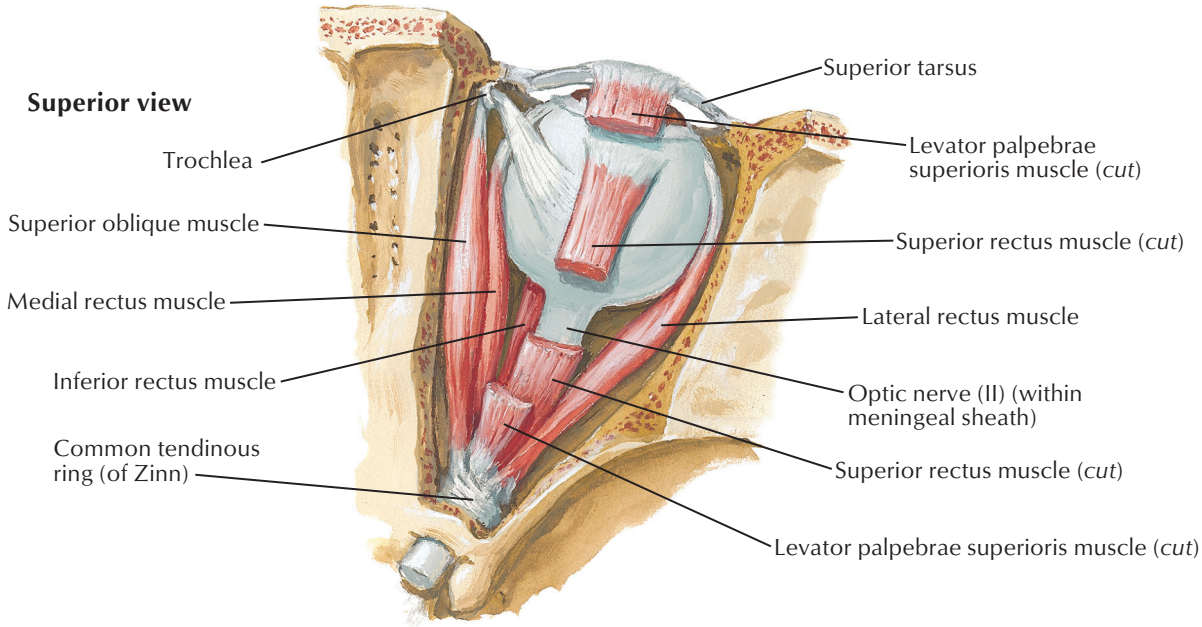
Muscle attachments and nerves and vessels entering orbit



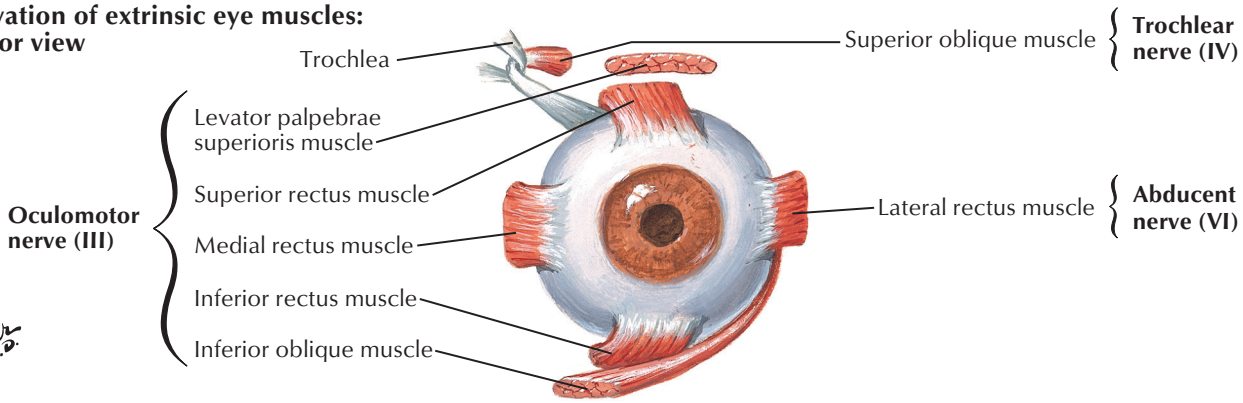
Right lateral view

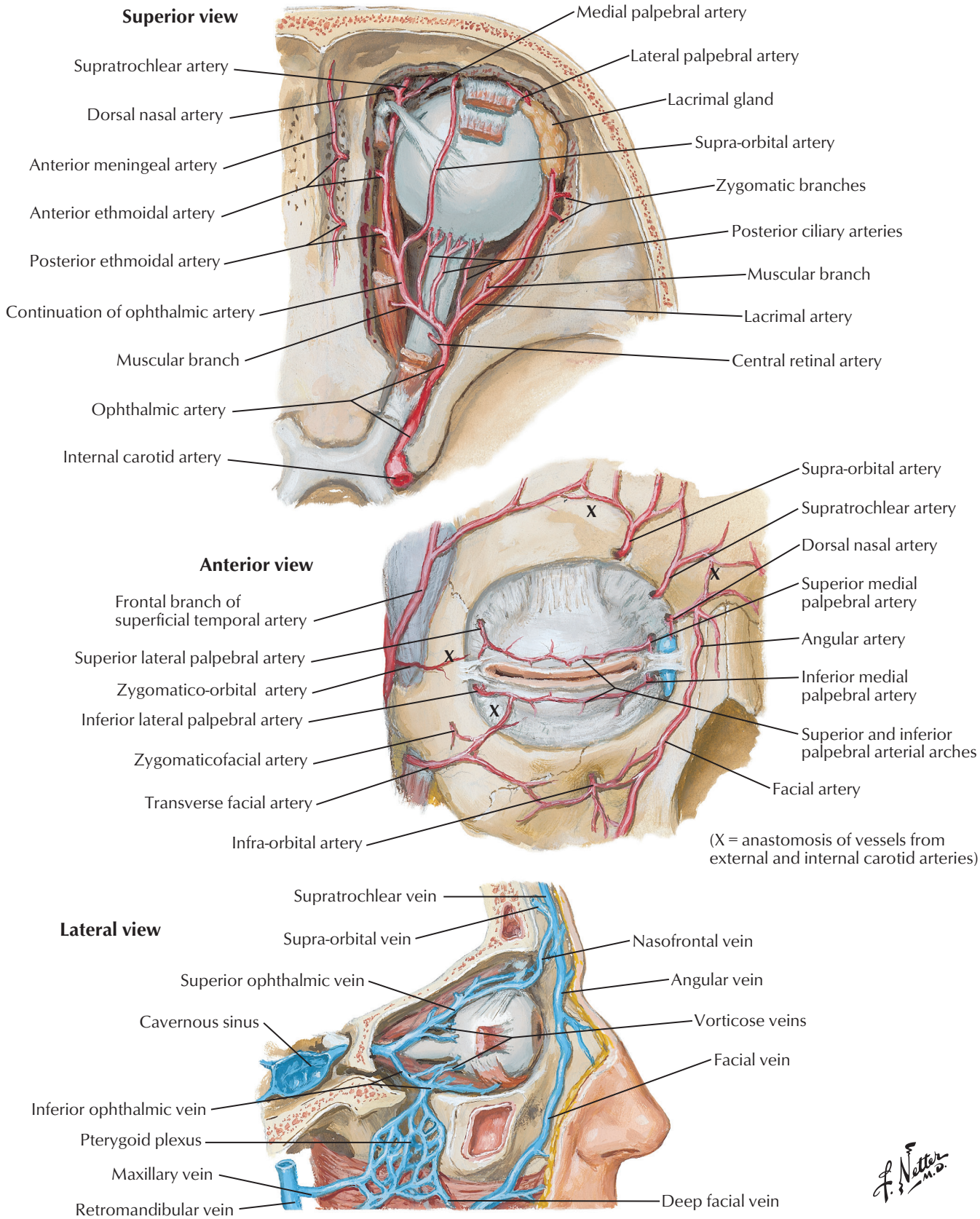


Superior view



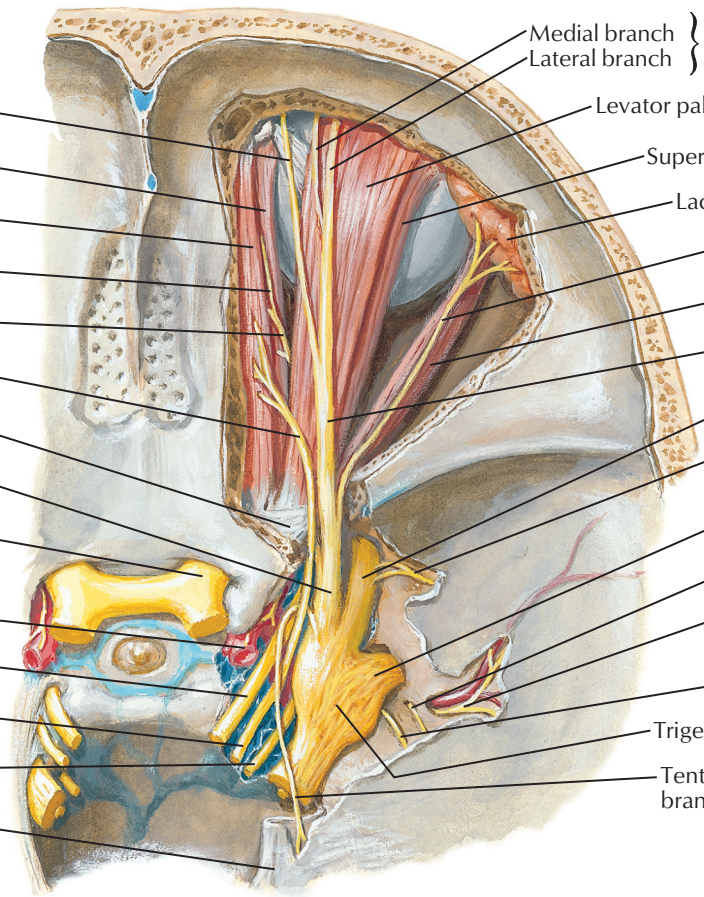
Innervation of extrinsic eye muscles: anterior view



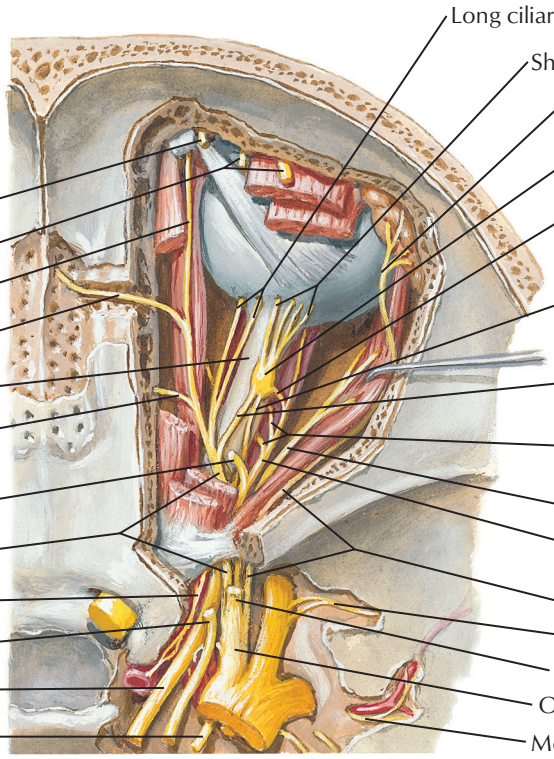

Superior view
Supratrochlear artery
Dorsal nasal artery
Anterior meningeal artery
Anterior ethmoidal artery
Posterior ethmoidal artery
Continuation of ophthalmic artery
Muscular branch
Ophthalmic artery
Internal carotid artery
Medial palpebral artery
Lateral palpebral artery
Lacrimal gland
Supra-orbital artery
Zygomatic branches
Posterior ciliary arteries
Muscular branch
Lacrimal artery
Central retinal artery
Anterior view
Frontal branch of superficial temporal artery
Superior lateral palpebral artery
Zygomatico-orbital artery
Inferior lateral palpebral artery
Zygomaticofacial artery
Transverse facial artery
Infra-orbital artery
X
Supra-orbital artery
Supratrochlear artery
Dorsal nasal artery
Superior medial palpebral artery
Angular artery
Inferior medial palpebral artery
Superior and inferior palpebral arterial arches
Facial artery
(X = anastomosis of vessels from external and internal carotid arteries)
Lateral view
Supratrochlear vein
Supra-orbital vein
Superior ophthalmic vein
Cavernous sinus
Inferior ophthalmic vein
Pterygoid plexus
Maxillary vein
Retromandibular vein
Nasofrontal vein
Angular vein
Vorticose veins
Facial vein
Deep facial vein

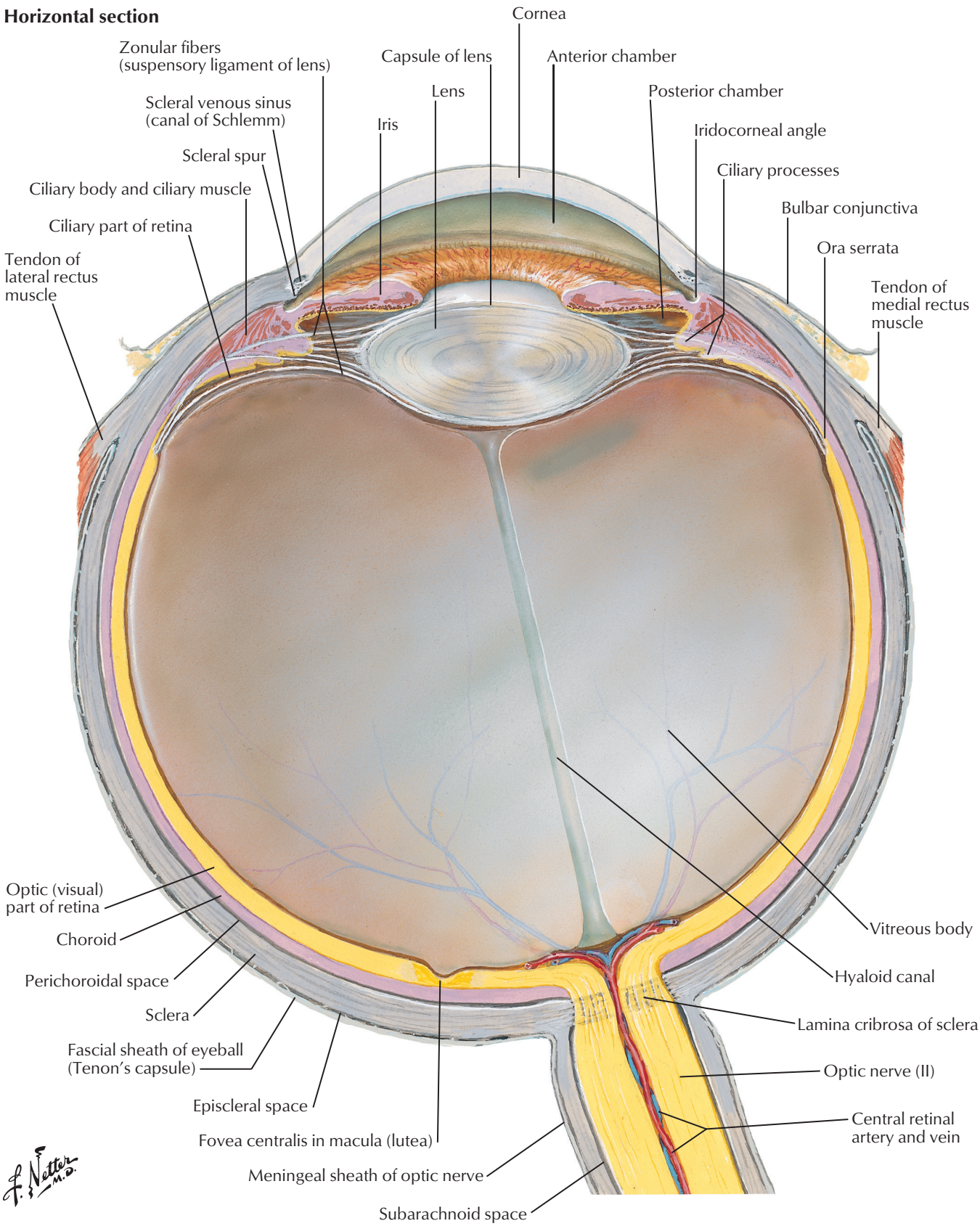
See also Plates 52, 122, 123

Superior view

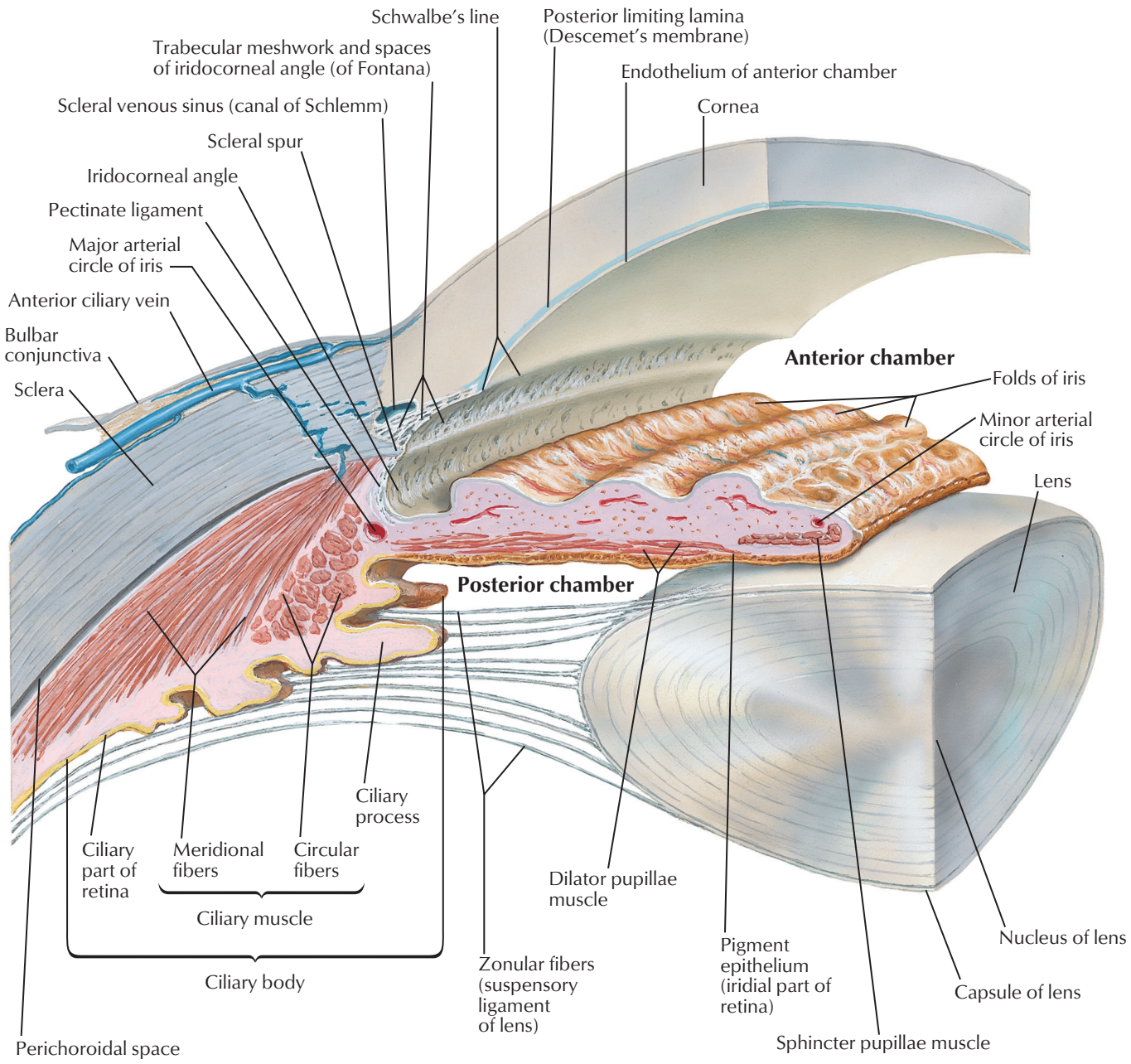


Superior view:
levator palpebrae superioris, superior rectus, and superior oblique muscles partially cut away

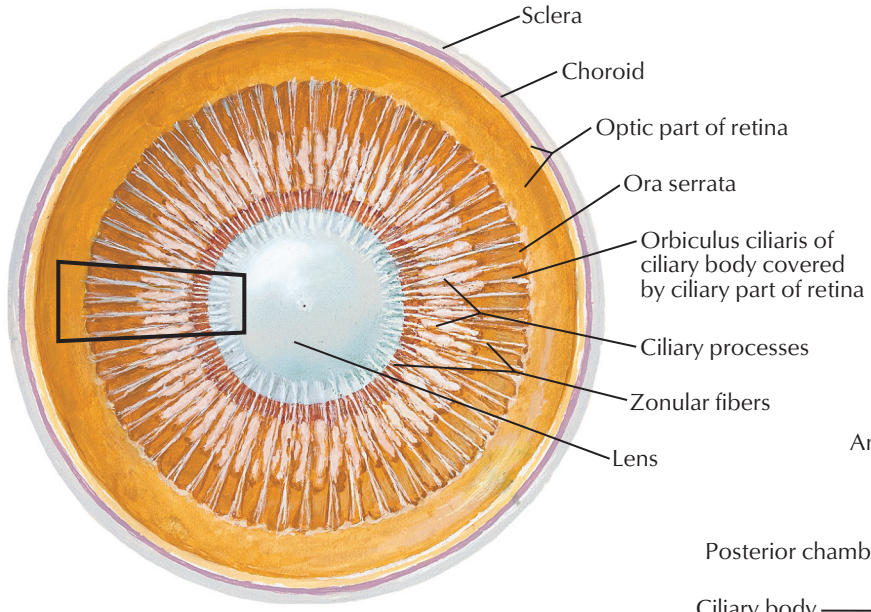



Horizontal section
Cornea
Zonular fibers (suspensory ligament of lens)
Capsule of lens
Anterior chamber
Lens
Posterior chamber
Scleral venous sinus (canal of Schlemm)
Iris
Iridocorneal angle
Scleral spur
Ciliary processes
Ciliary body and ciliary muscle
Bulbar conjunctiva
Ciliary part of retina
Ora serrata
Tendon of lateral rectus muscle
Tendon of medial rectus muscle
Optic (visual) part of retina
Vitreous body
Choroid
Hyaloid canal
Perichoroidal space
Lamina cribrosa of sclera
Sclera
Optic nerve (II)
Fascial sheath of eyeball (Tenon's capsule)
Central retinal artery and vein
Episcleral space
Fovea centralis in macula (lutea)
Meningeal sheath of optic nerve
Subarachnoid space

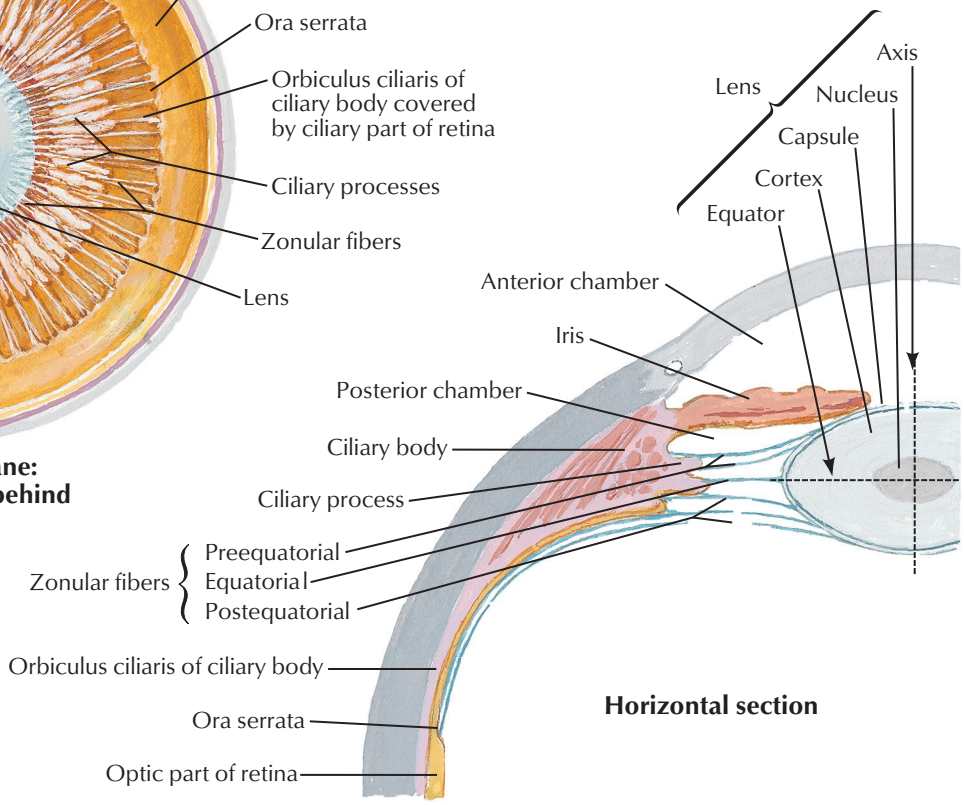
Anterior and Posterior Chambers of Eye



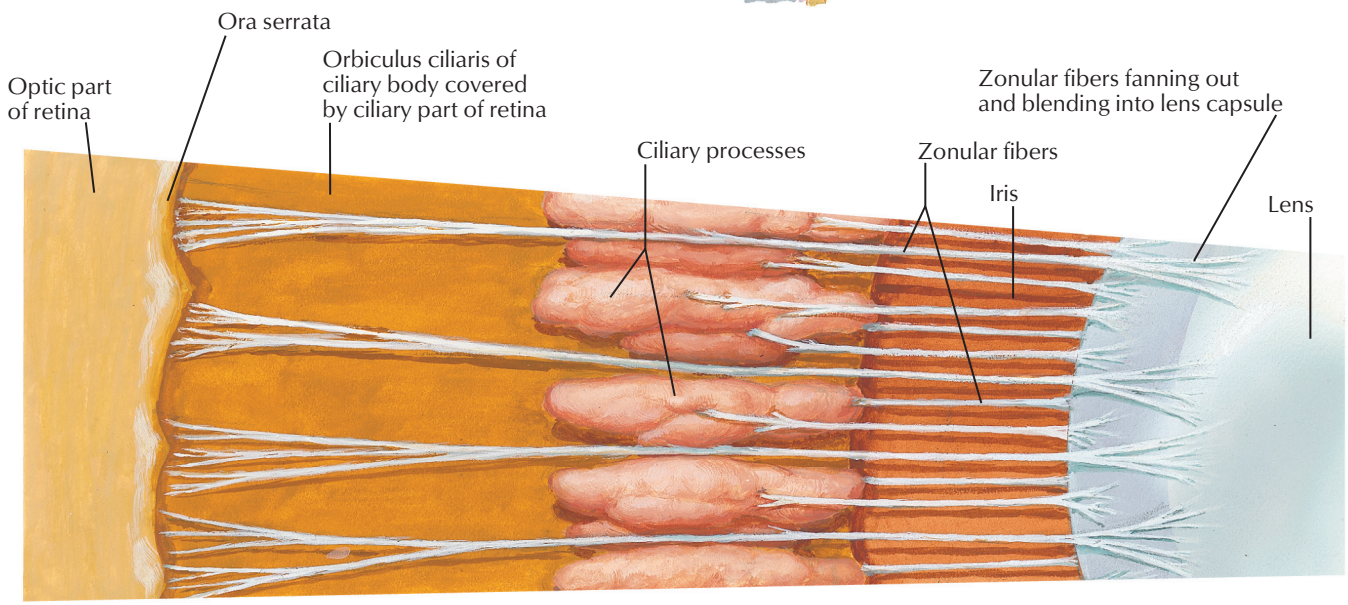
Note: For clarity, only single plane of zonular fibers shown; actually, fibers surround entire circumference of lens.



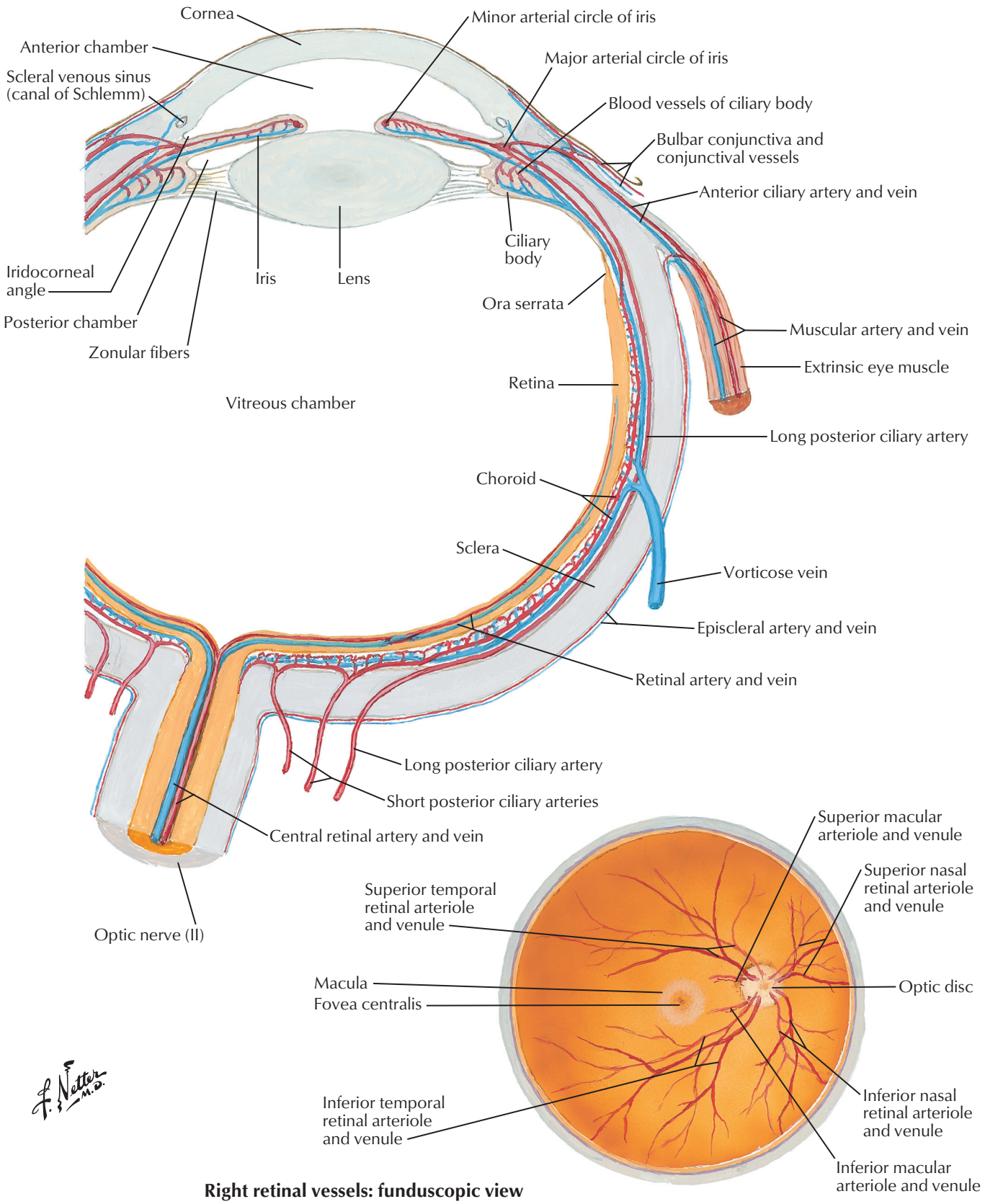
Eyeball sectioned in coronal plane: anterior segment viewed from behind



Horizontal section

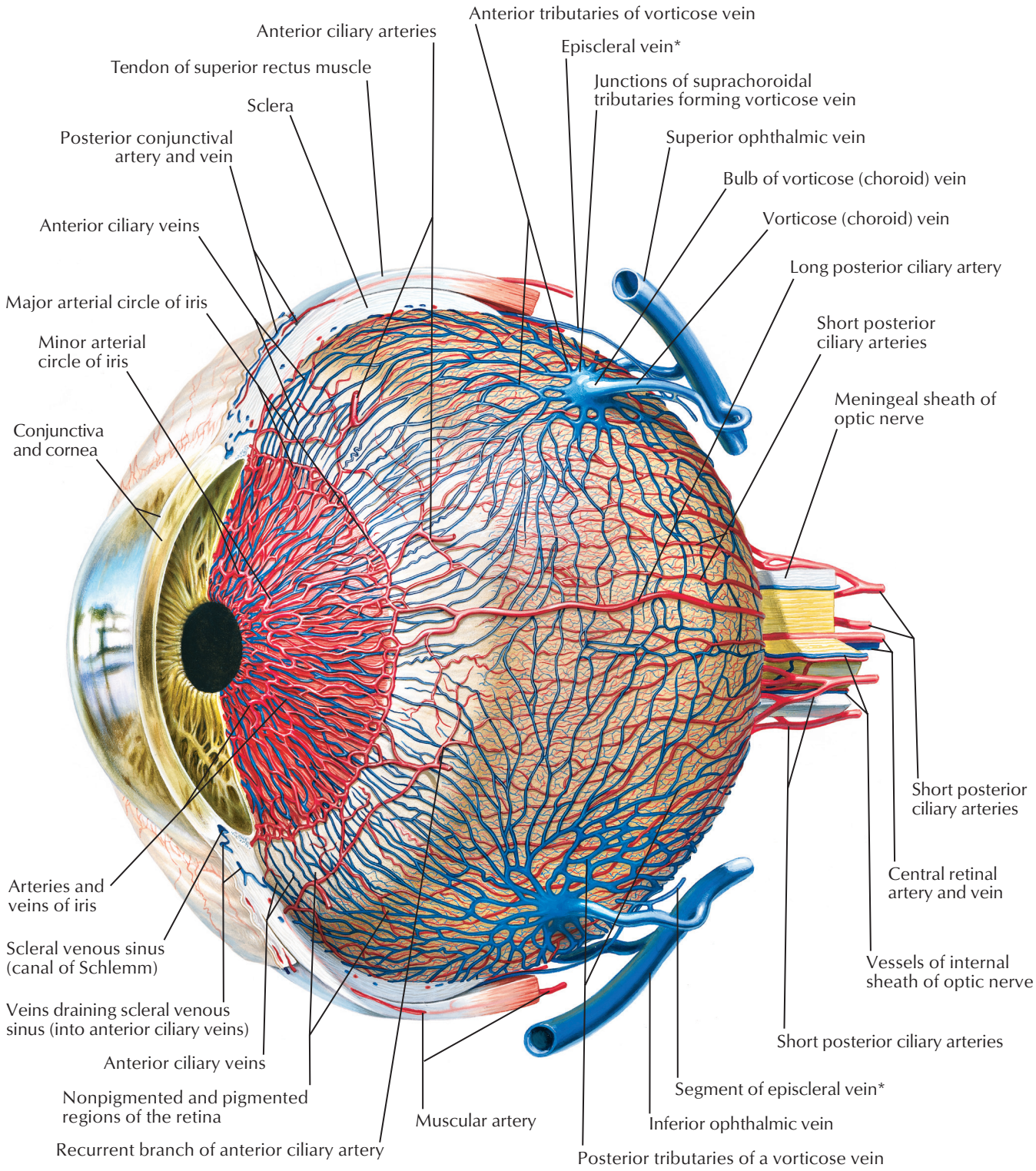


Enlargement of segment outlined in top illustration (semischematic)



Right retinal vessels: funduscopic view

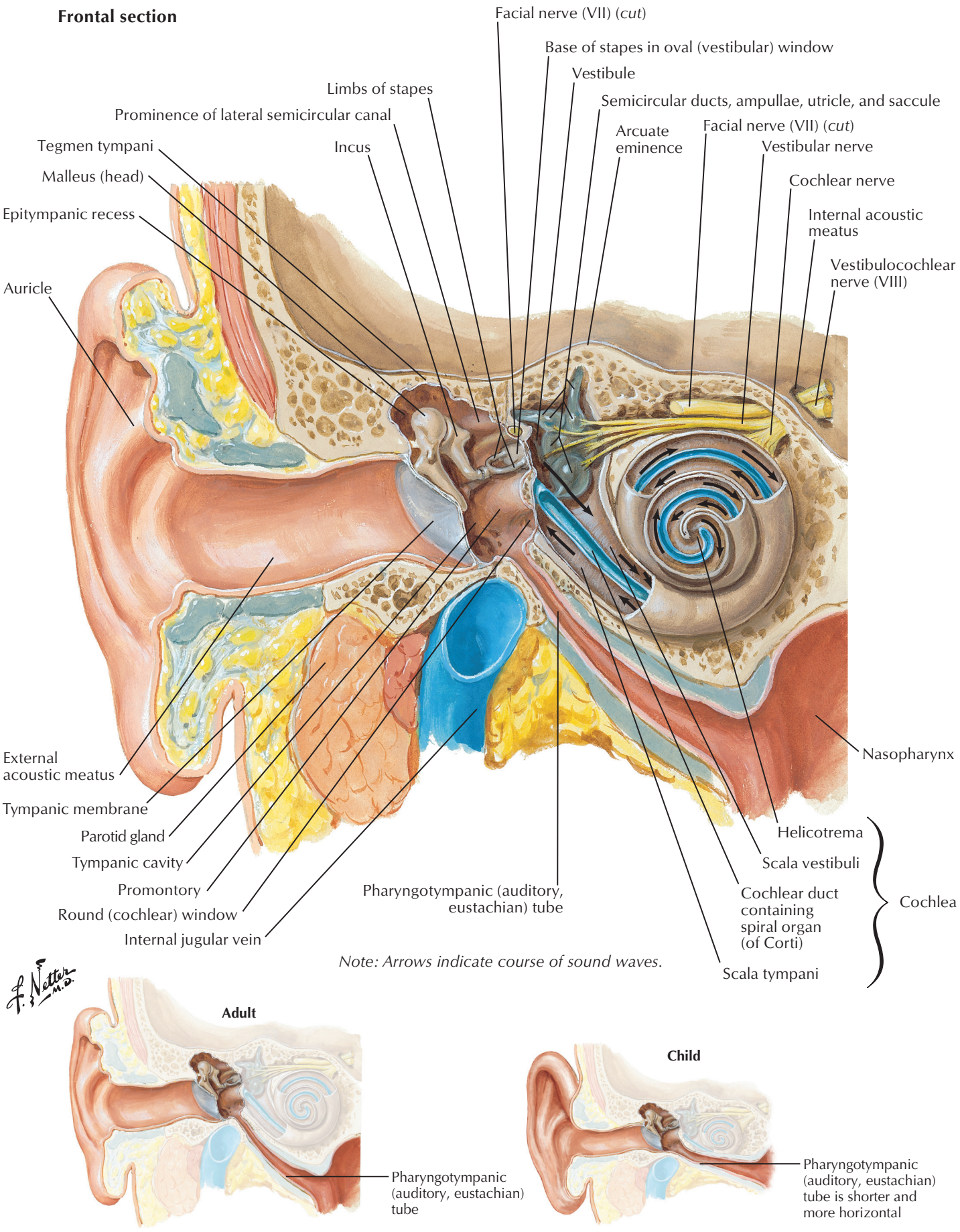
Vascular arrangements within the choroid (vascular tunic) of the eyeball



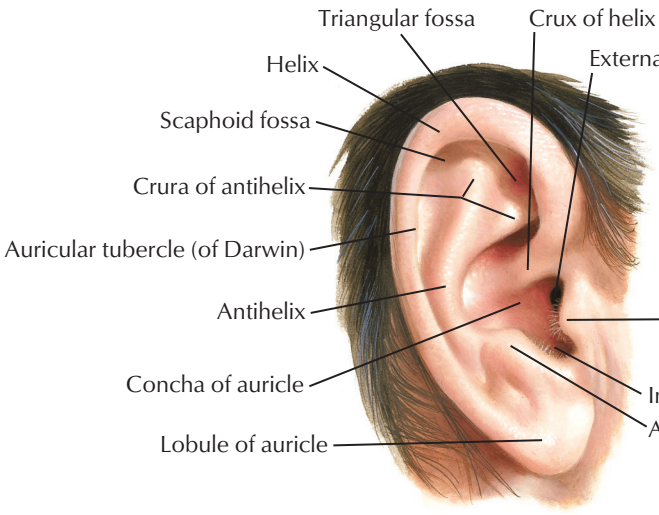
*The episcleral veins are shown here anastomosing with the vorticose veins, which they do; however, they also drain into the anterior ciliary veins.

C. Machado M.D.

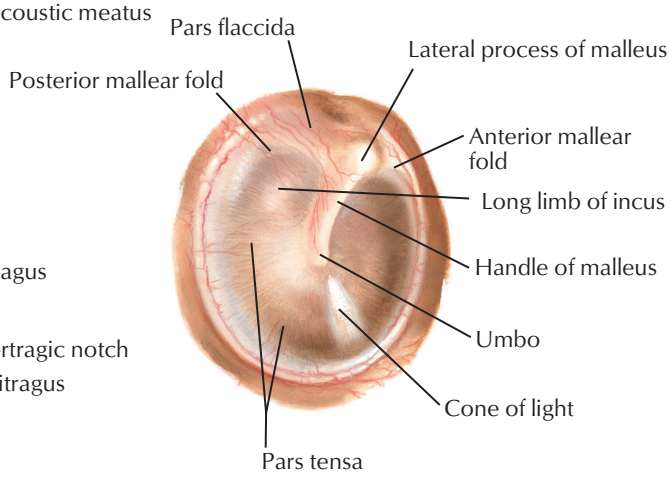
Pathway of Sound Reception



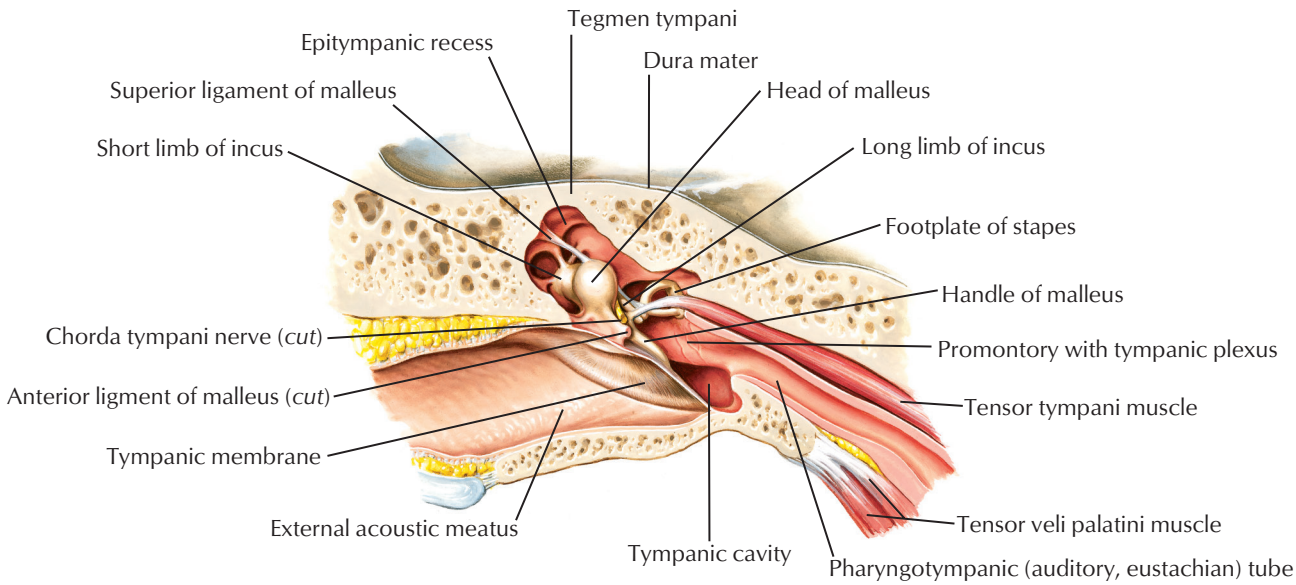
Right auricle (pinna)



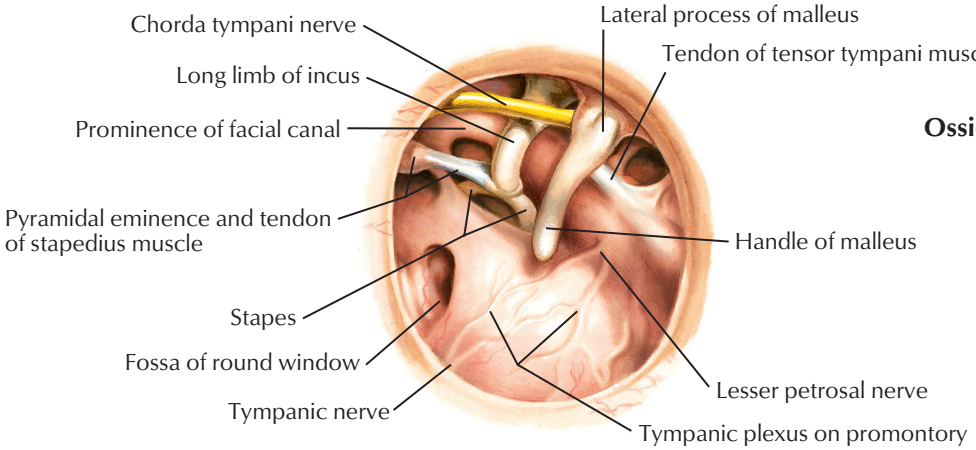
Otoscopic view of right tympanic membrane



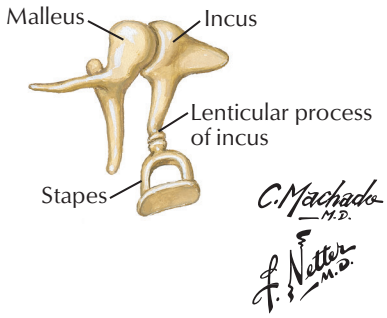
Coronal oblique section of external acoustic meatus and middle ear (tympanic cavity)



Right tympanic cavity after removal of tympanic membrane (lateral view)

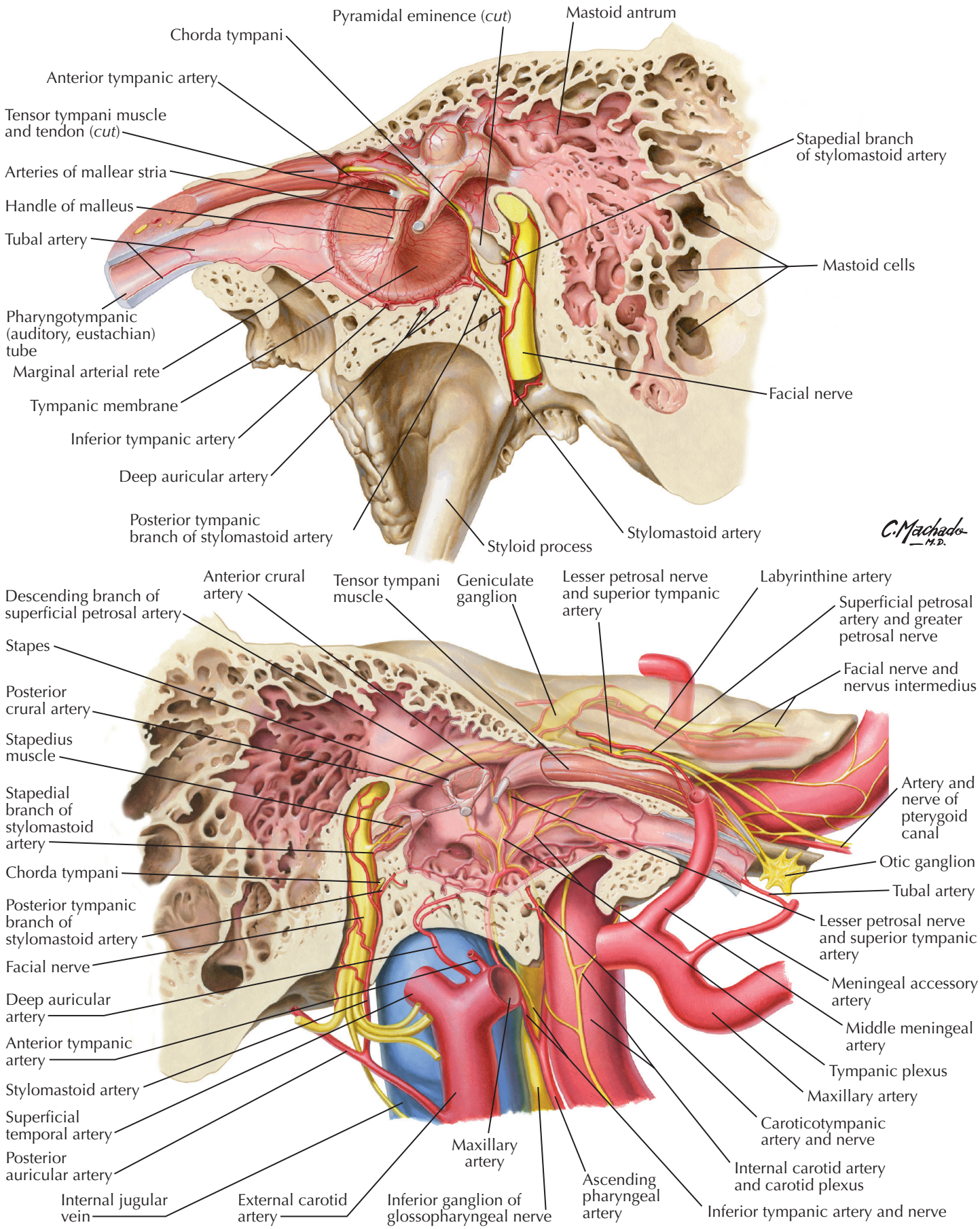


Ossicles articulated: medial view

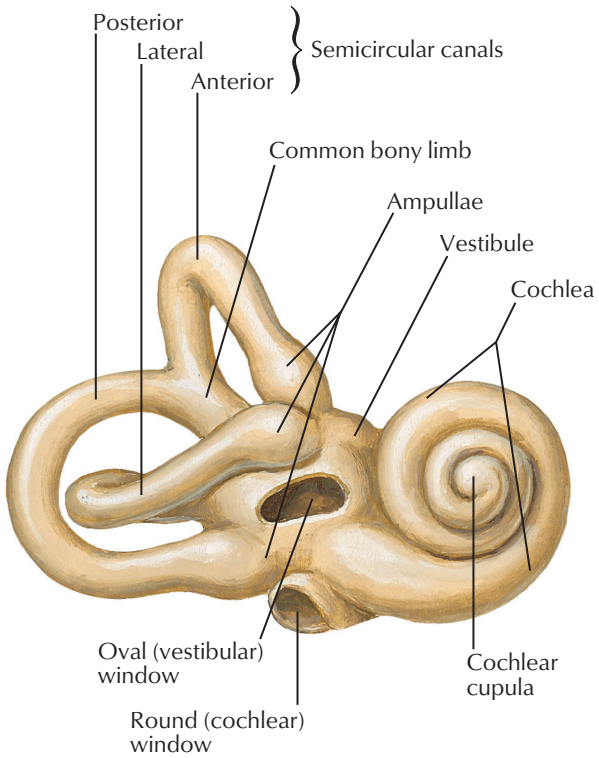


Tympanic Cavity

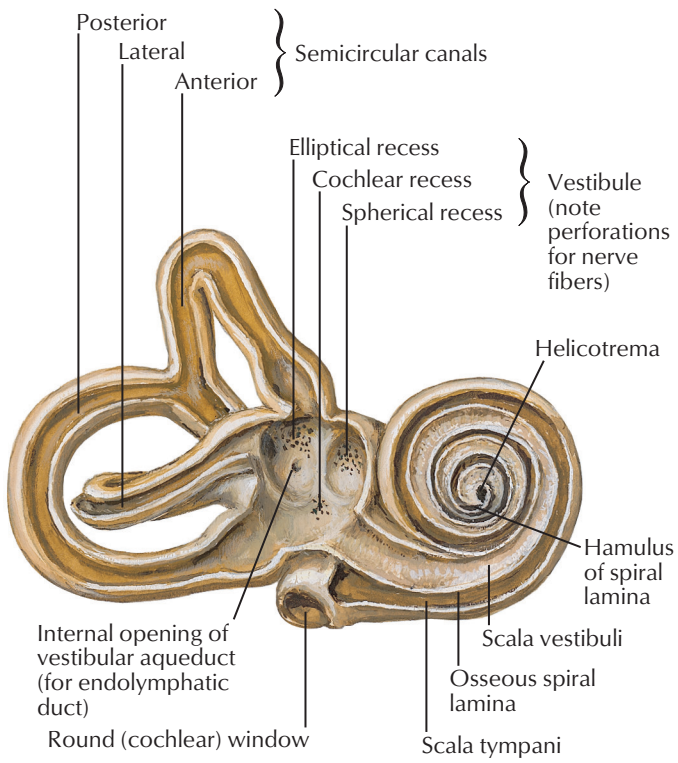
See also Plates 50, 124, 136



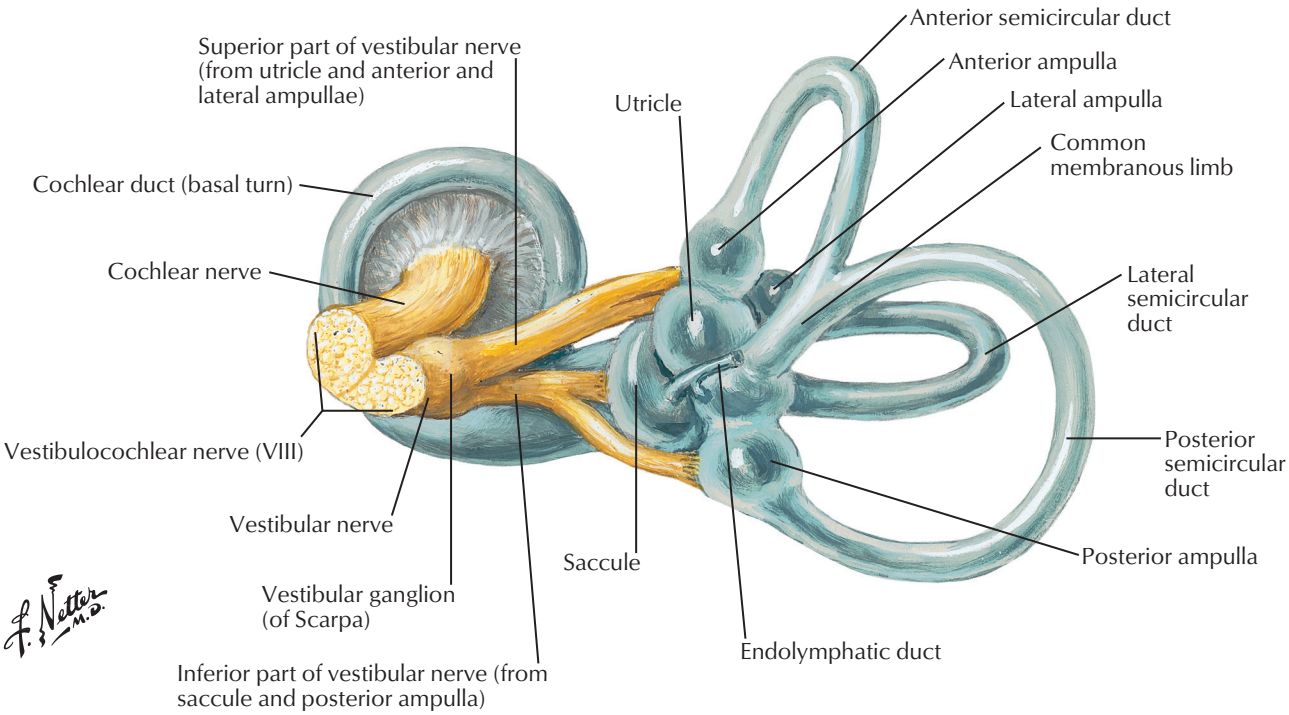
Right bony labyrinth (otic capsule), anterolateral view: surrounding cancellous bone removed



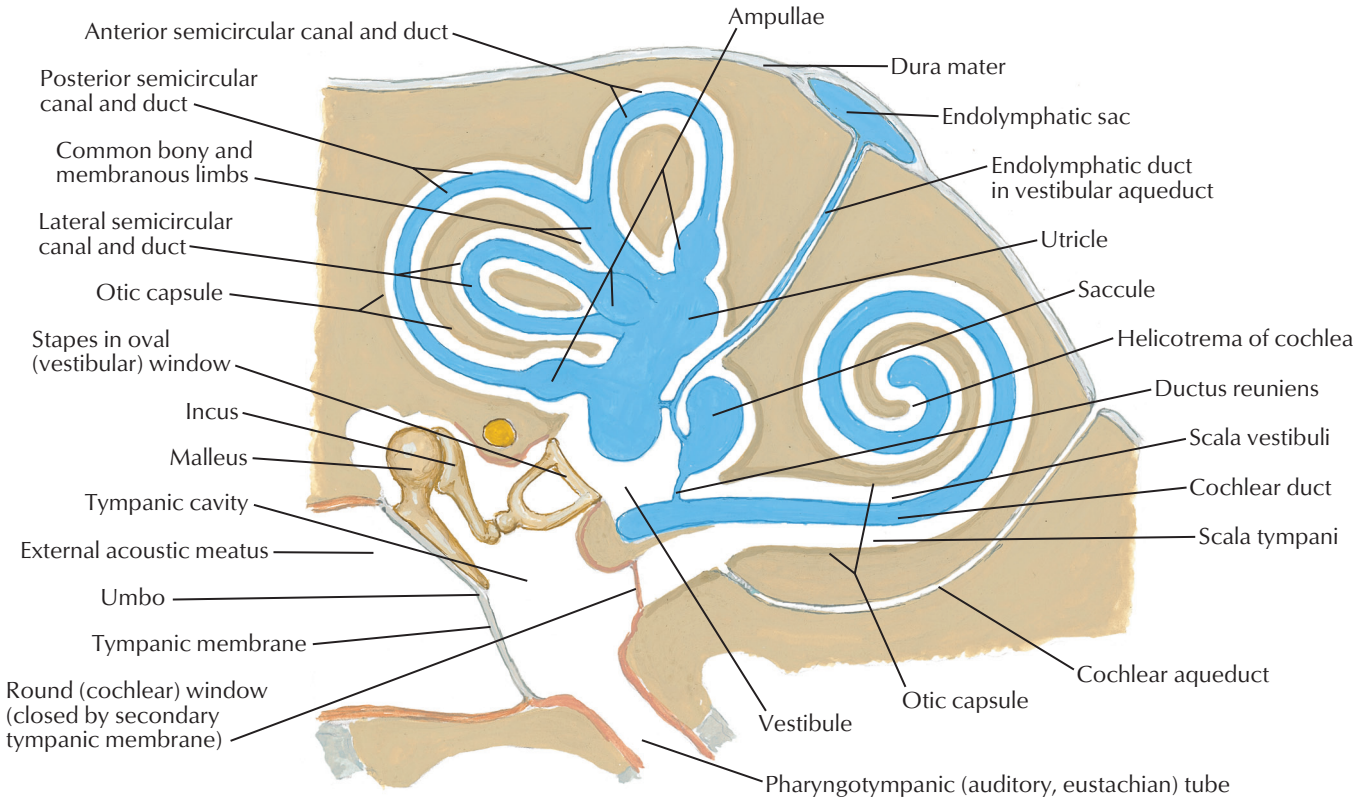
Dissected right bony labyrinth (otic capsule): membranous labyrinth removed



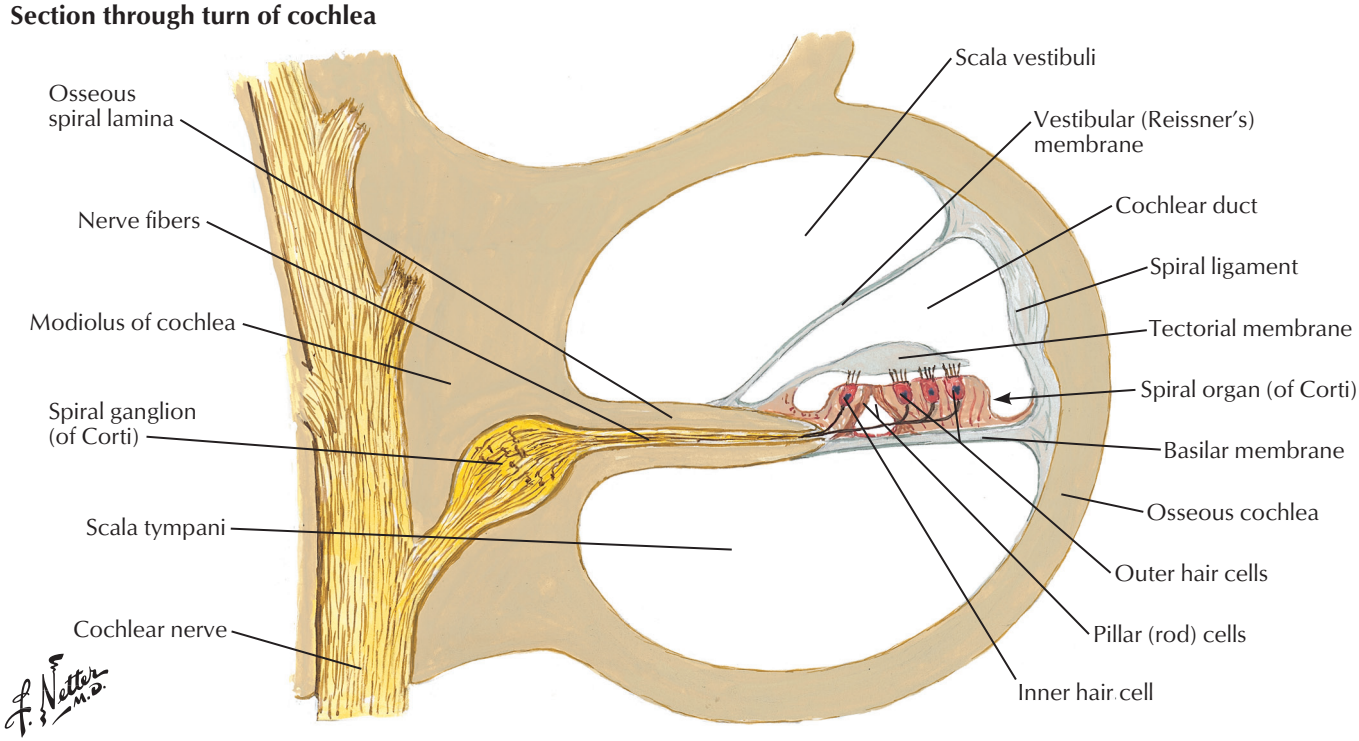
Right membranous labyrinth with nerves: medial view



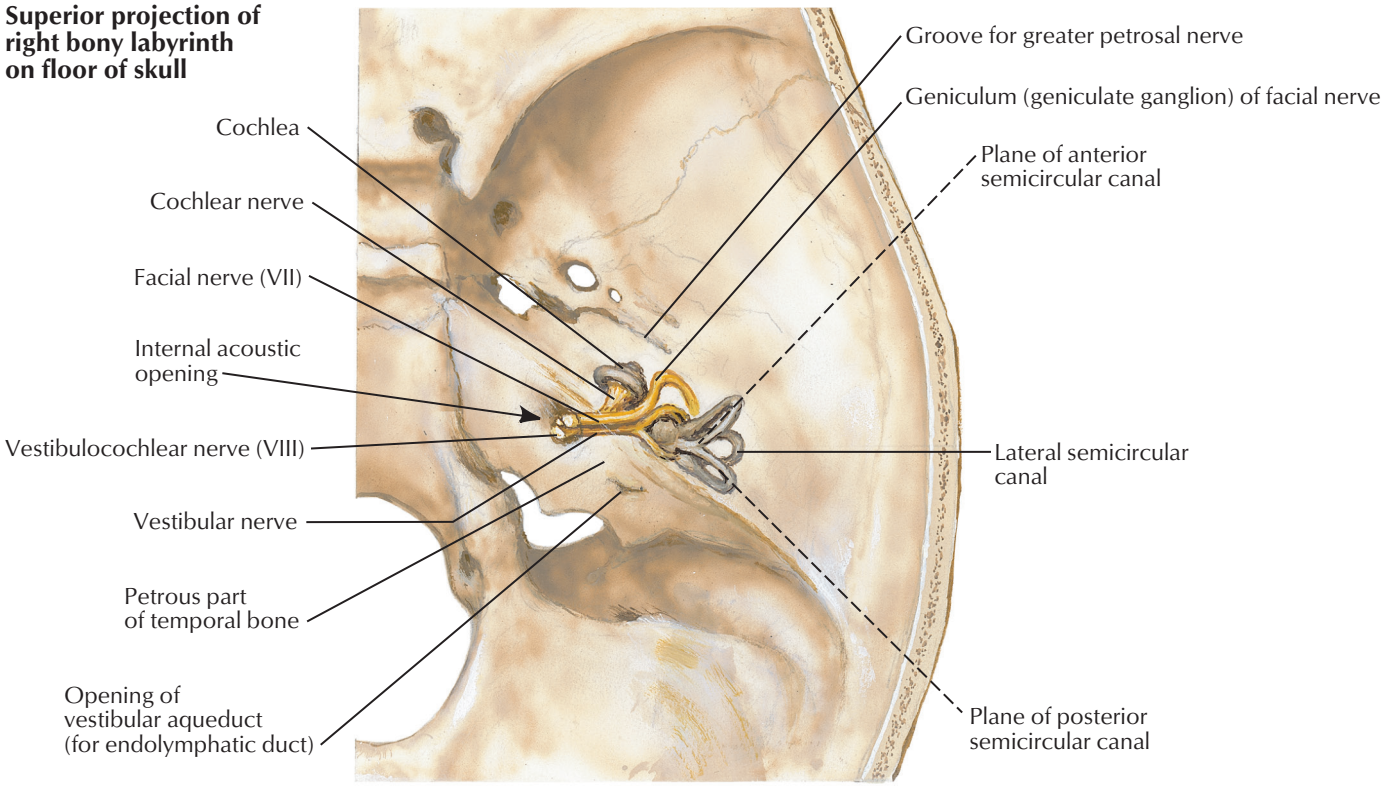
Bony and membranous labyrinths: schema



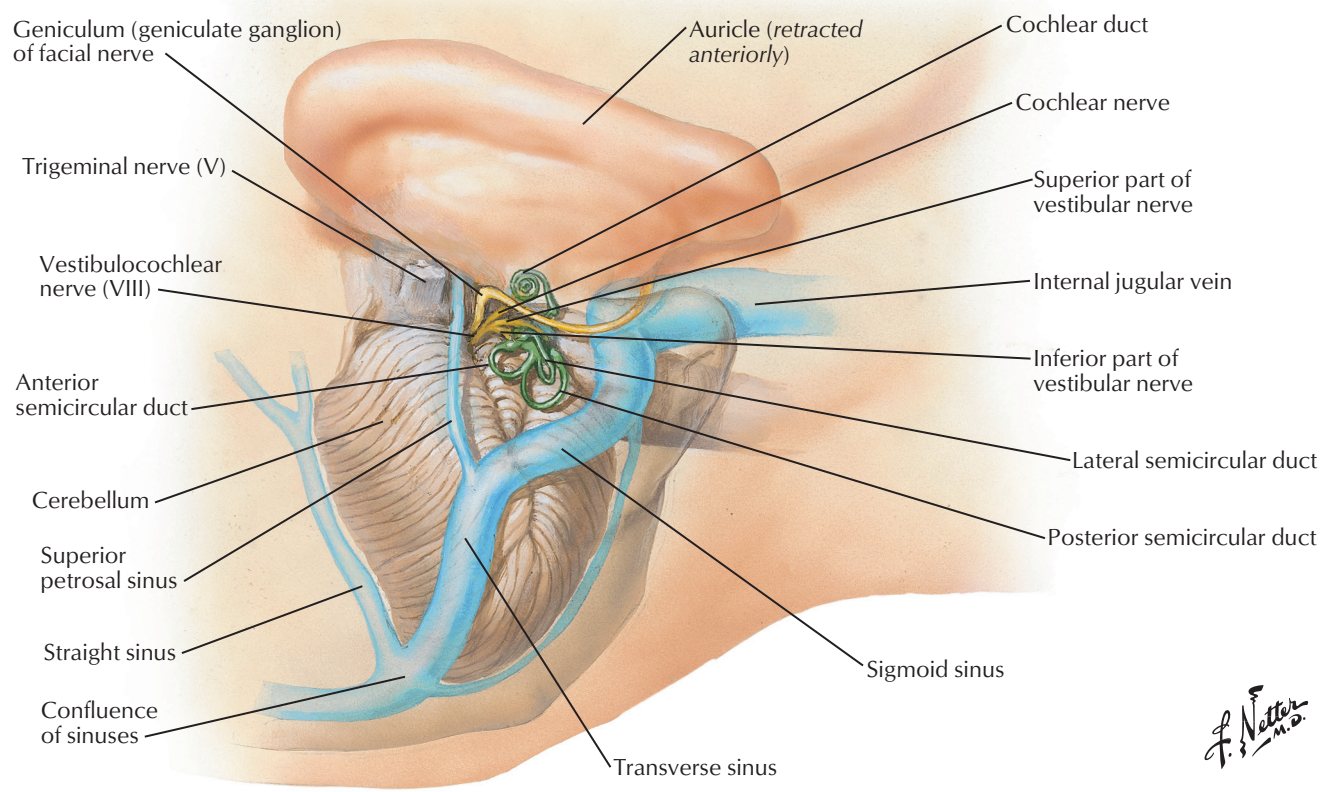
Section through turn of cochlea



Superior projection of right bony labyrinth on floor of skull



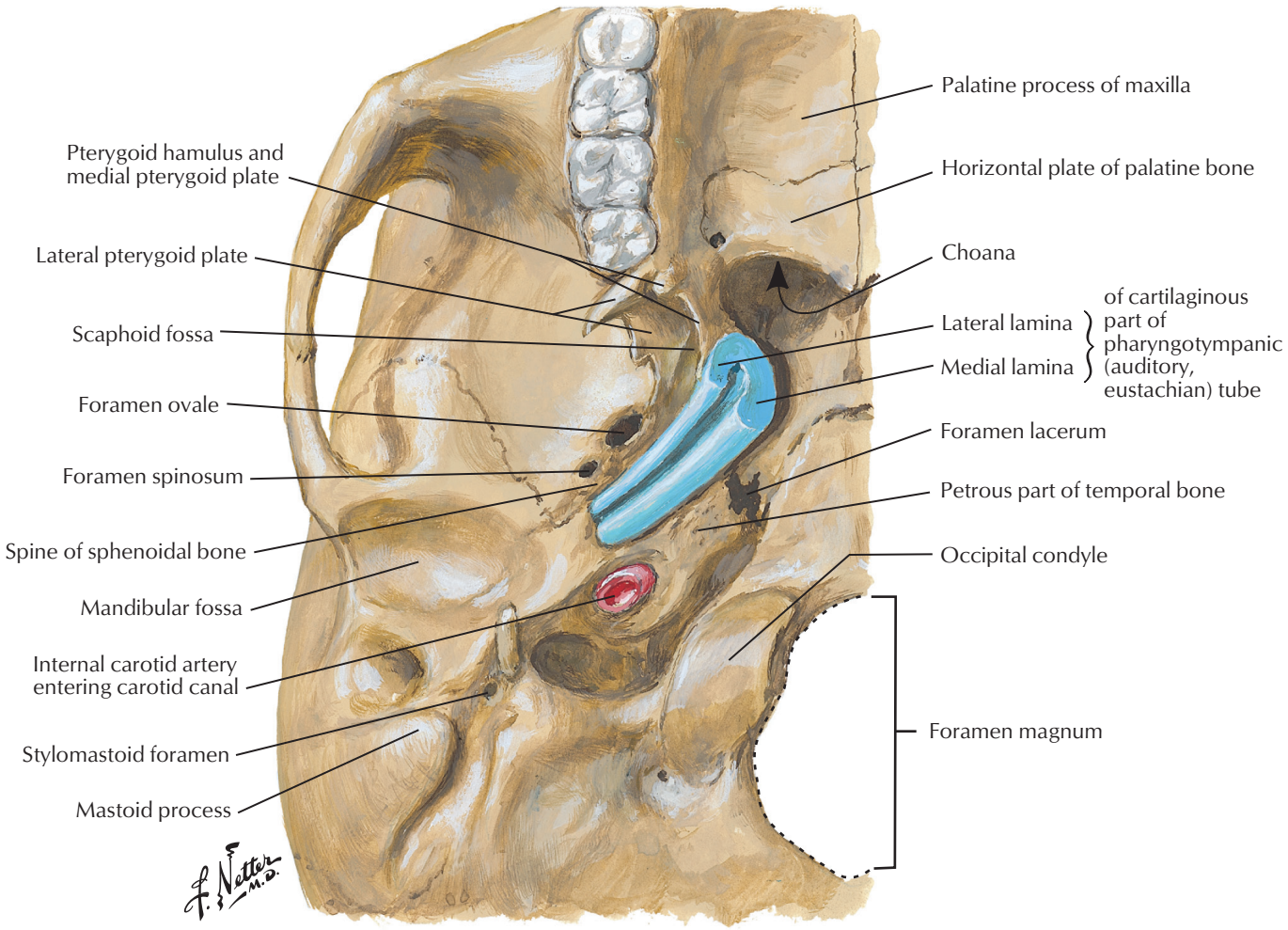
Lateral projection of right membranous labyrinth

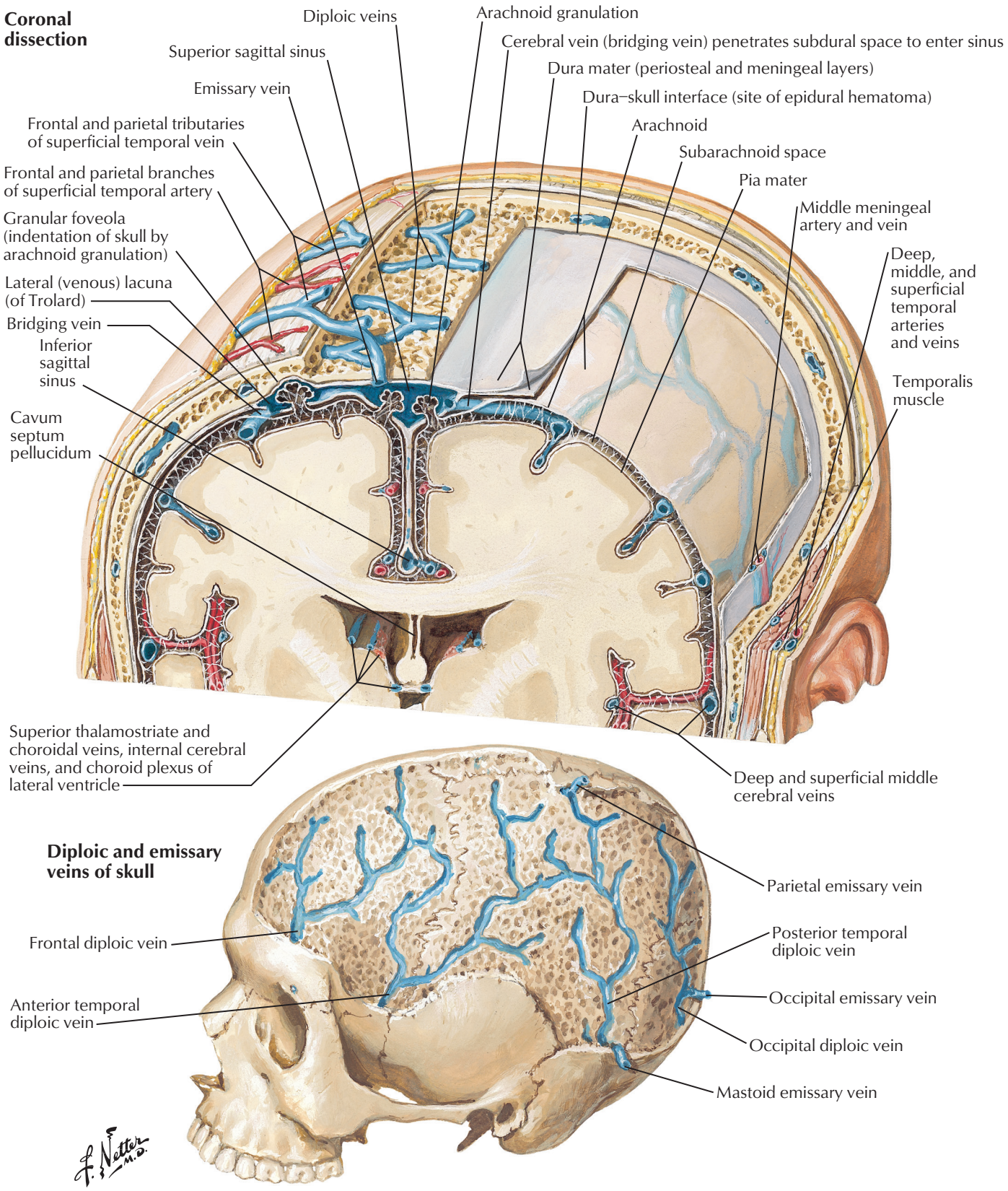


Pharyngotympanic (Auditory, Eustachian) Tube

See also Plate 49

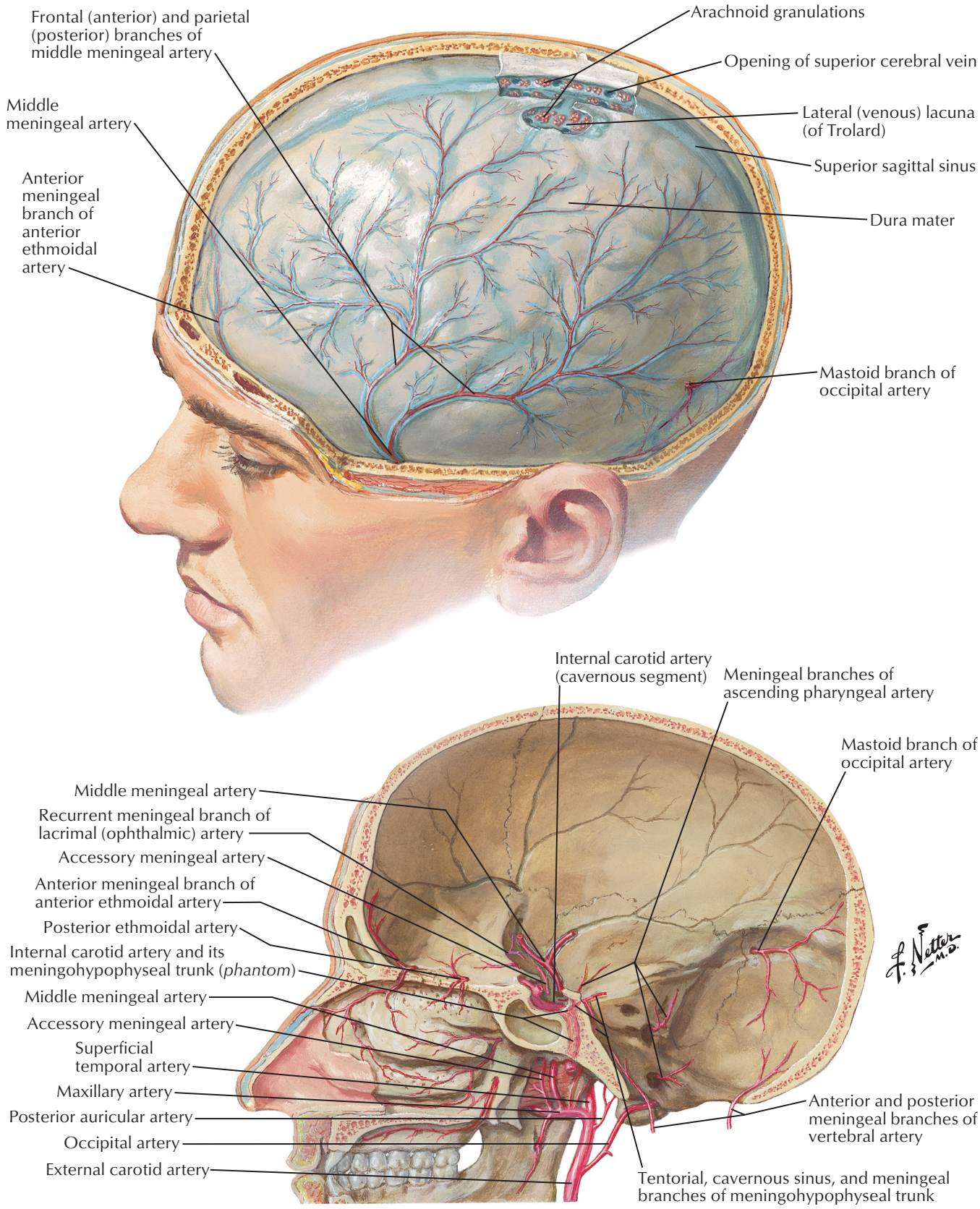
Cartilaginous part of pharyngotympanic (auditory, eustachian) tube at base of skull: inferior view

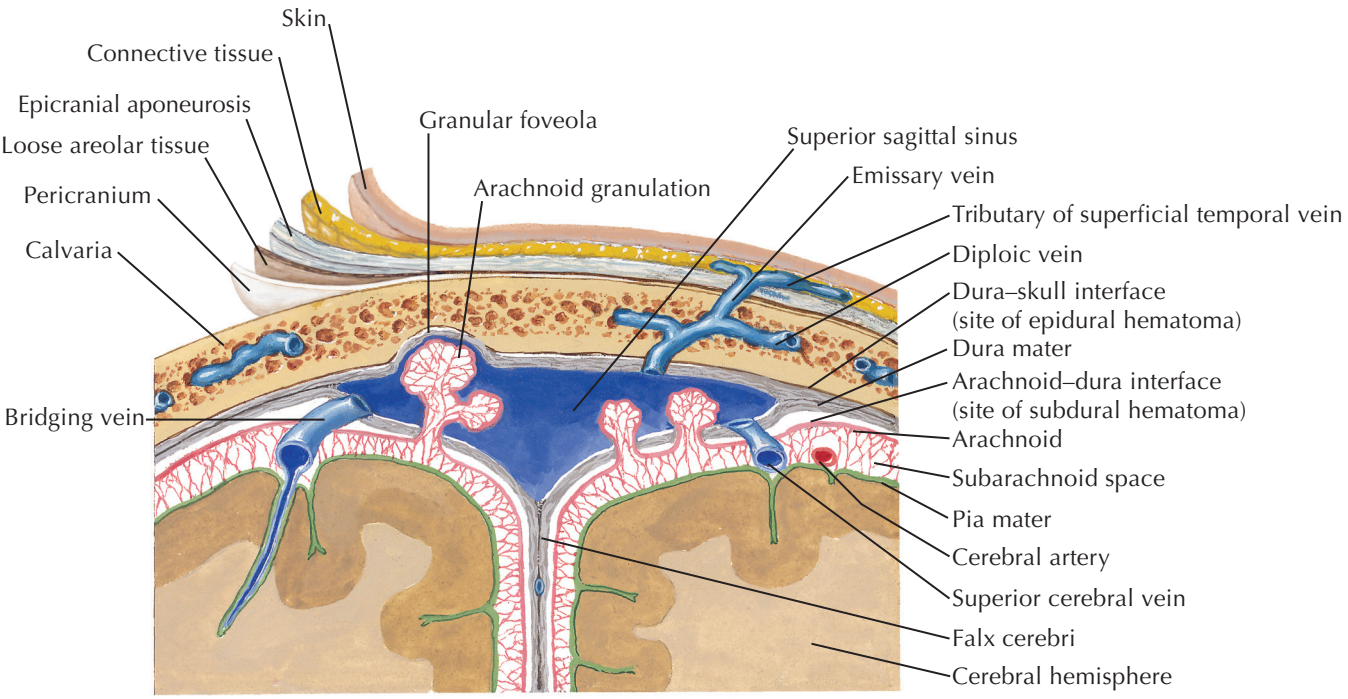


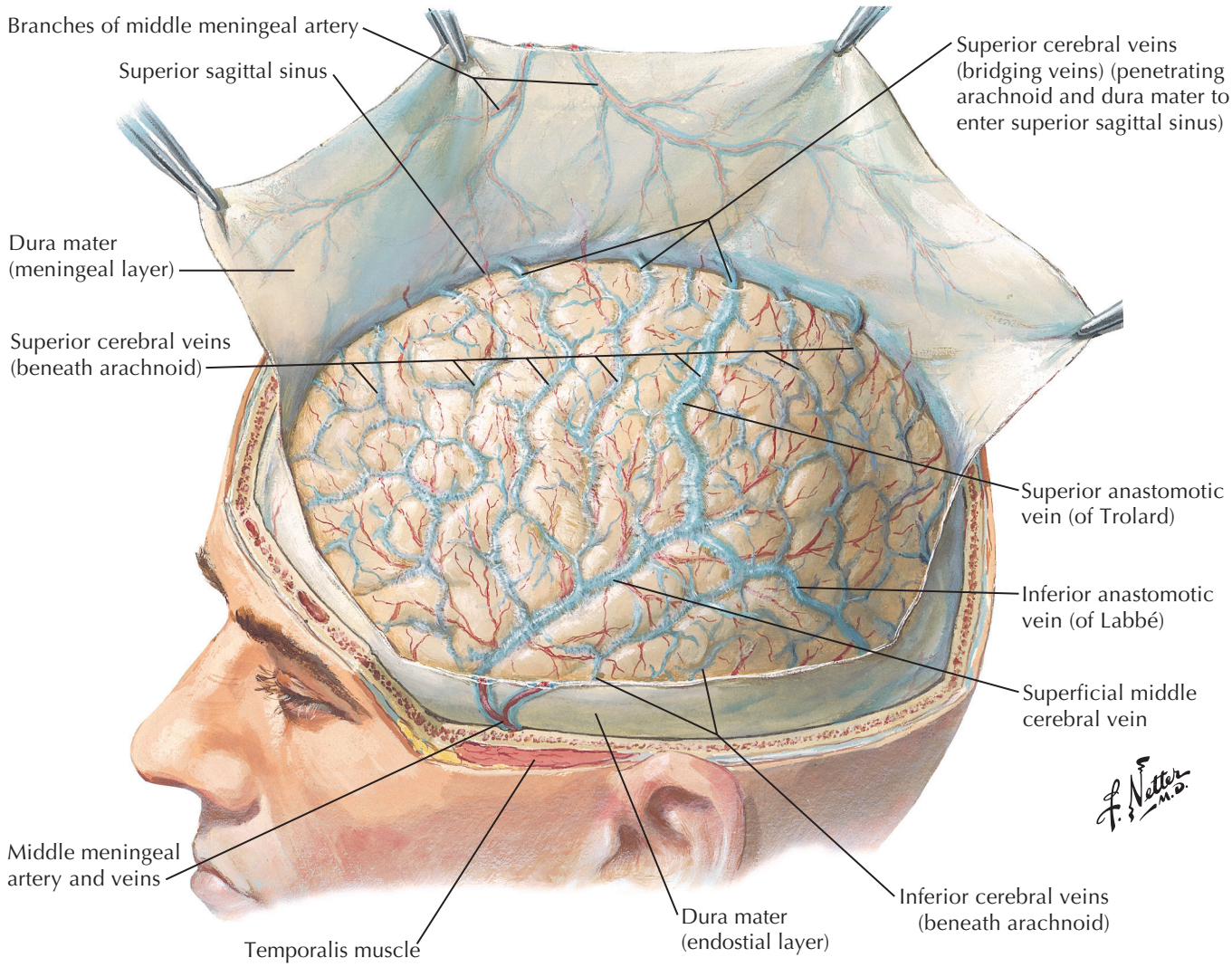

Coronal dissection
Diploic veins
Arachnoid granulation
Superior sagittal sinus
Cerebral vein (bridging vein) penetrates subdural space to enter sinus
Dura mater (periosteal and meningeal layers)
Emissary vein
Dura–skull interface (site of epidural hematoma)
Frontal and parietal tributaries of superficial temporal vein
Arachnoid
Subarachnoid space
Frontal and parietal branches of superficial temporal artery
Pia mater
Middle meningeal artery and vein
Granular foveola (indentation of skull by arachnoid granulation)
Deep, middle, and superficial temporal arteries and veins
Lateral (venous) lacuna (of Trolard)
Bridging vein
Inferior sagittal sinus
Temporalis muscle
Cavum septum pellucidum
Superior thalamostriate and choroidal veins, internal cerebral veins, and choroid plexus of lateral ventricle
Deep and superficial middle cerebral veins
Diploic and emissary veins of skull
Parietal emissary vein
Frontal diploic vein
Posterior temporal diploic vein
Anterior temporal diploic vein
Occipital emissary vein
Occipital diploic vein
Mastoid emissary vein

Meningeal Arteries

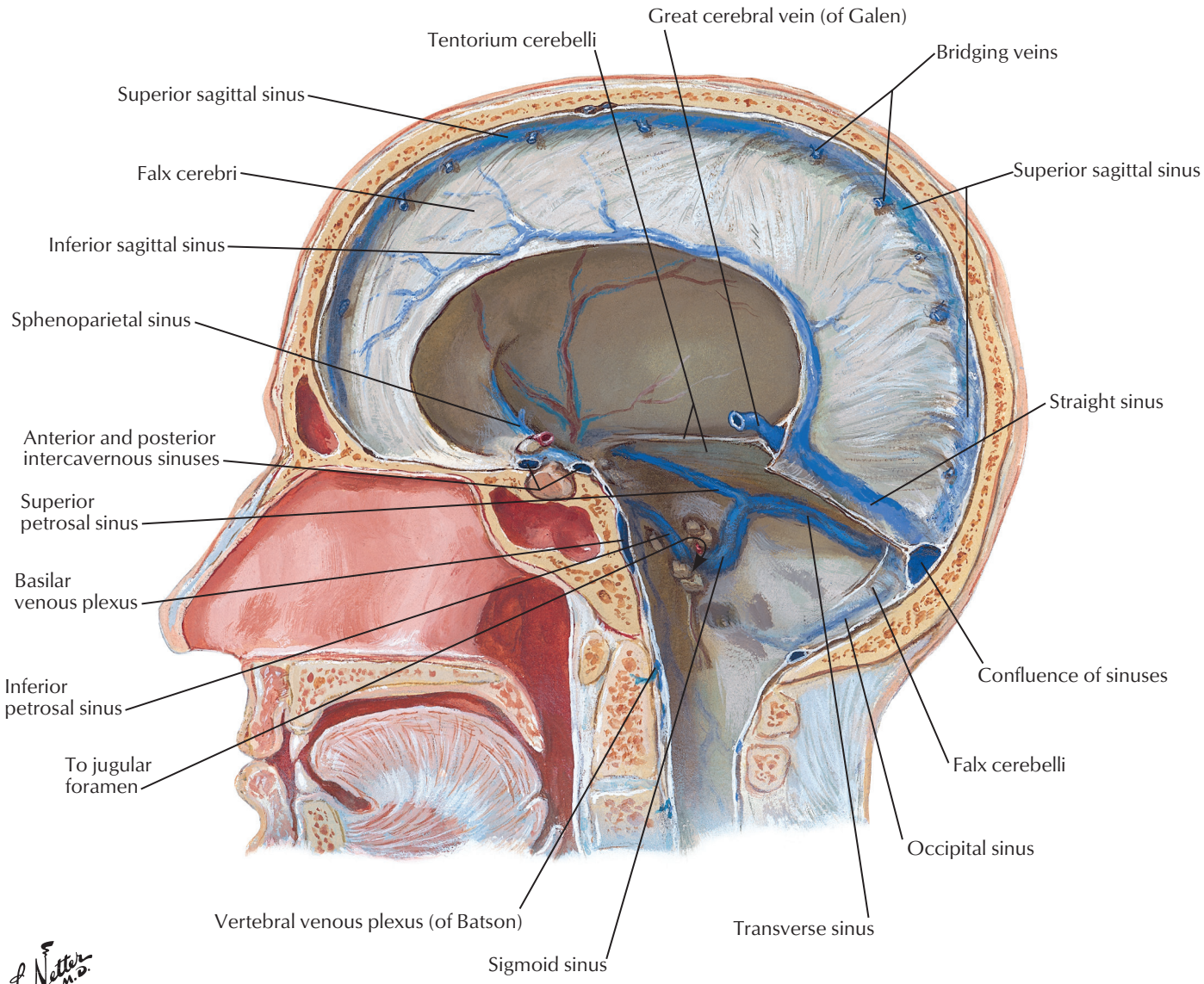
See also Plates 9, 51, 137



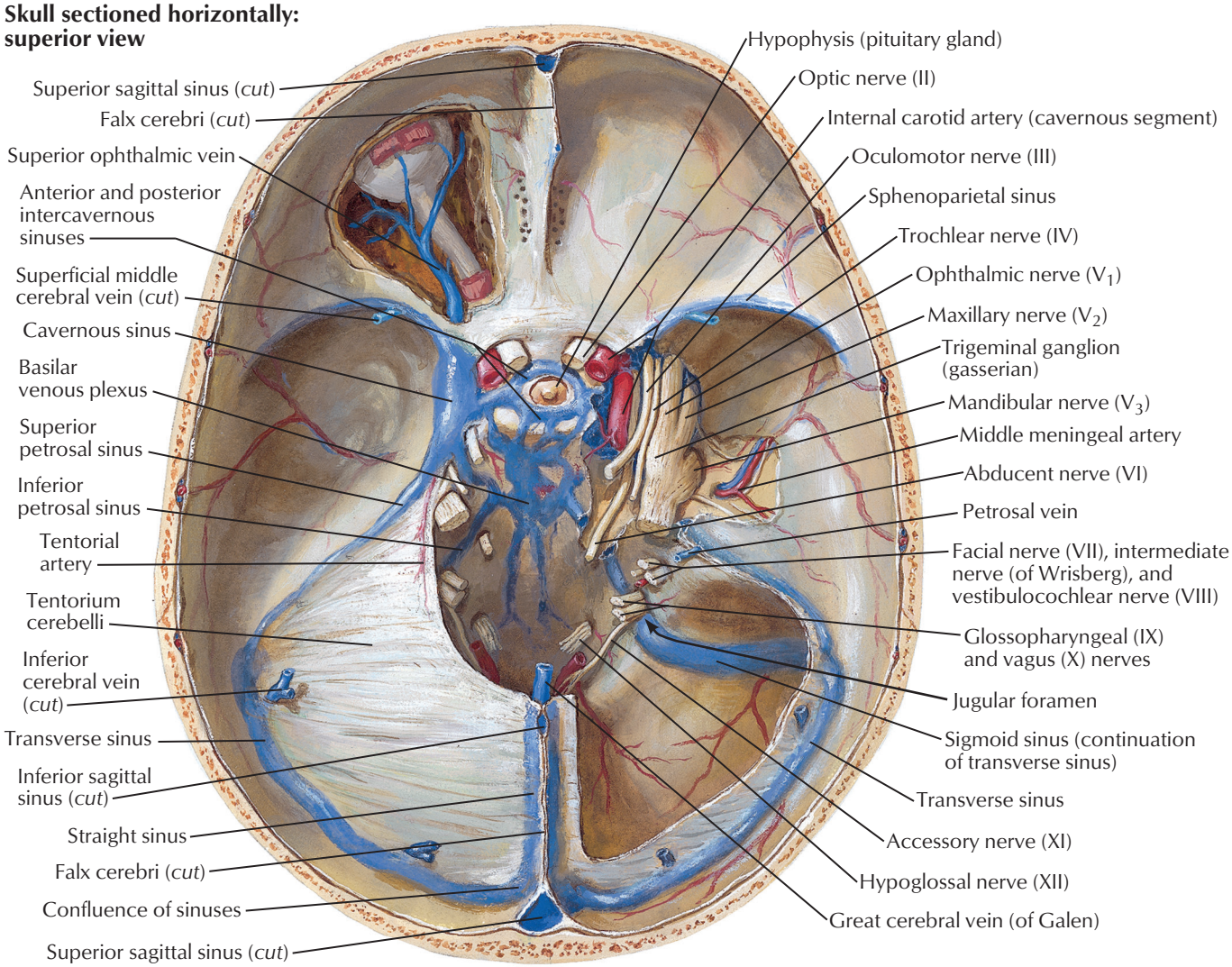

Skin
Connective tissue
Epicranial aponeurosis
Loose areolar tissue
Pericranium
Calvaria
Bridging vein
Granular foveola
Arachnoid granulation
Superior sagittal sinus
Emissary vein
Tributary of superficial temporal vein
Diploic vein
Dura–skull interface
(site of epidural hematoma)
Dura mater
Arachnoid–dura interface
(site of subdural hematoma)
Arachnoid
Subarachnoid space
Pia mater
Cerebral artery
Superior cerebral vein
Falx cerebri
Cerebral hemisphere

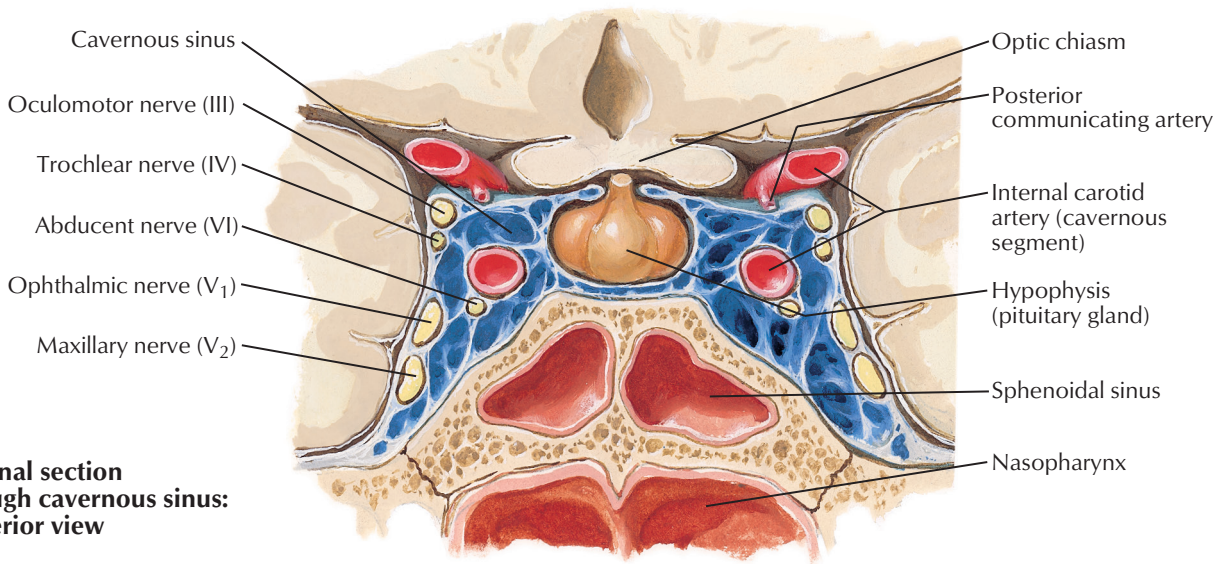

Branches of middle meningeal artery
Superior sagittal sinus
Superior cerebral veins
(bridging veins) (penetrating
arachnoid and dura mater to
enter superior sagittal sinus)
Dura mater
(meningeal layer)
Superior cerebral veins
(beneath arachnoid)
Superior anastomotic
vein (of Trolard)
Inferior anastomotic
vein (of Labbé)
Superficial middle
cerebral vein
Middle meningeal
artery and veins
Temporalis muscle
Dura mater
(endostial layer)
Inferior cerebral veins
(beneath arachnoid)

Sagittal section

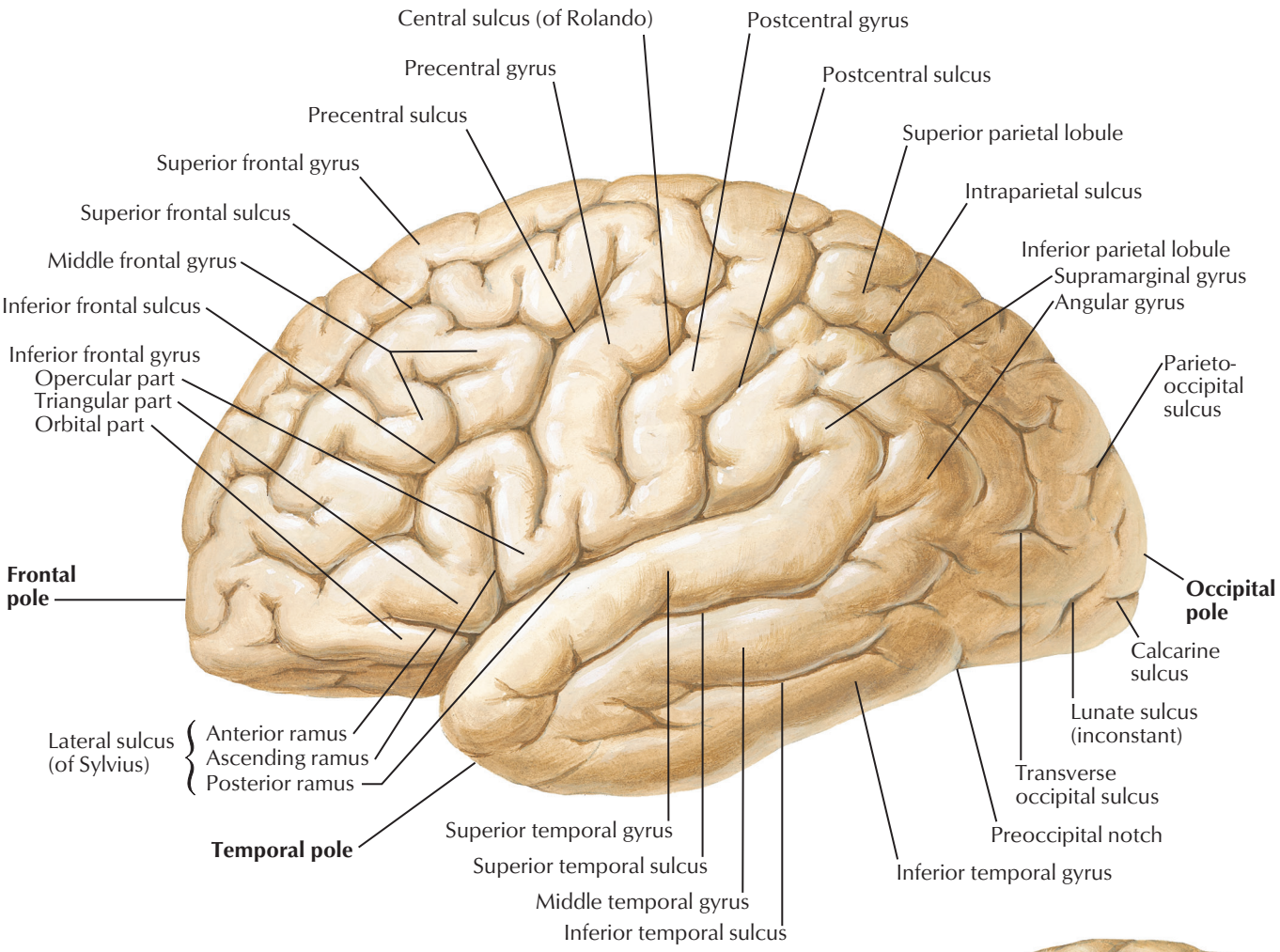


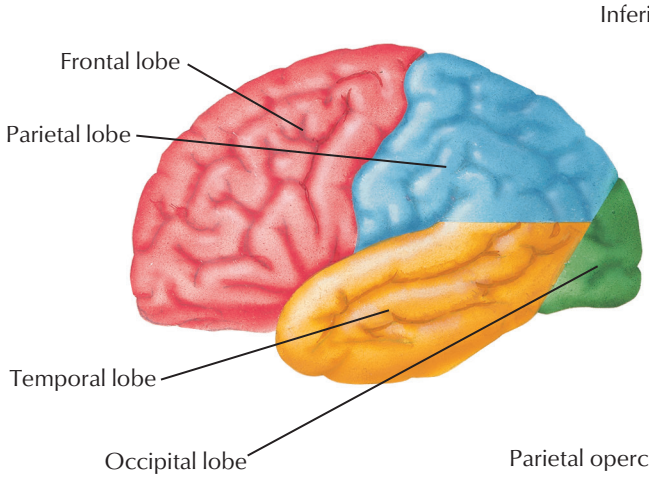
Skull sectioned horizontally: superior view

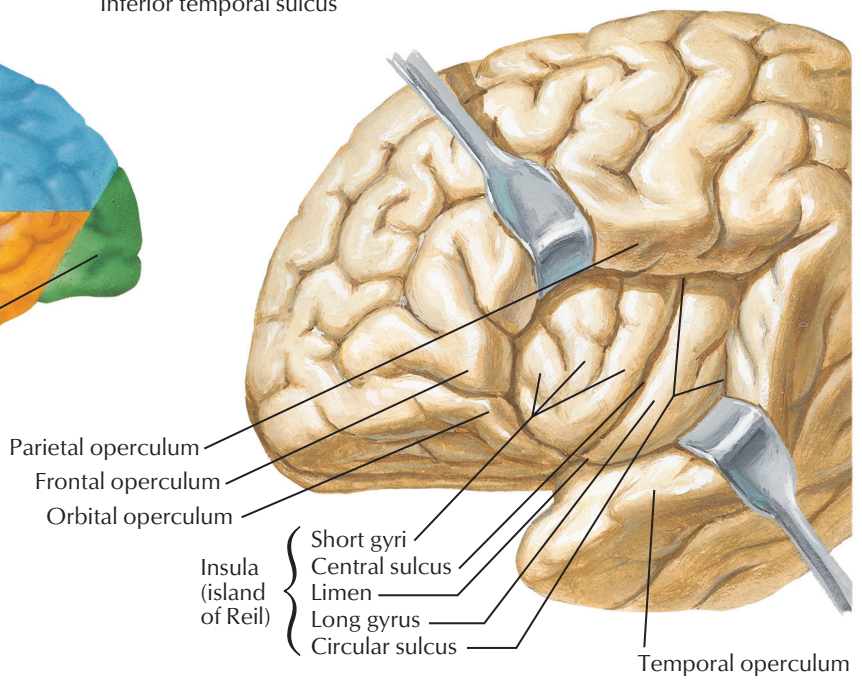




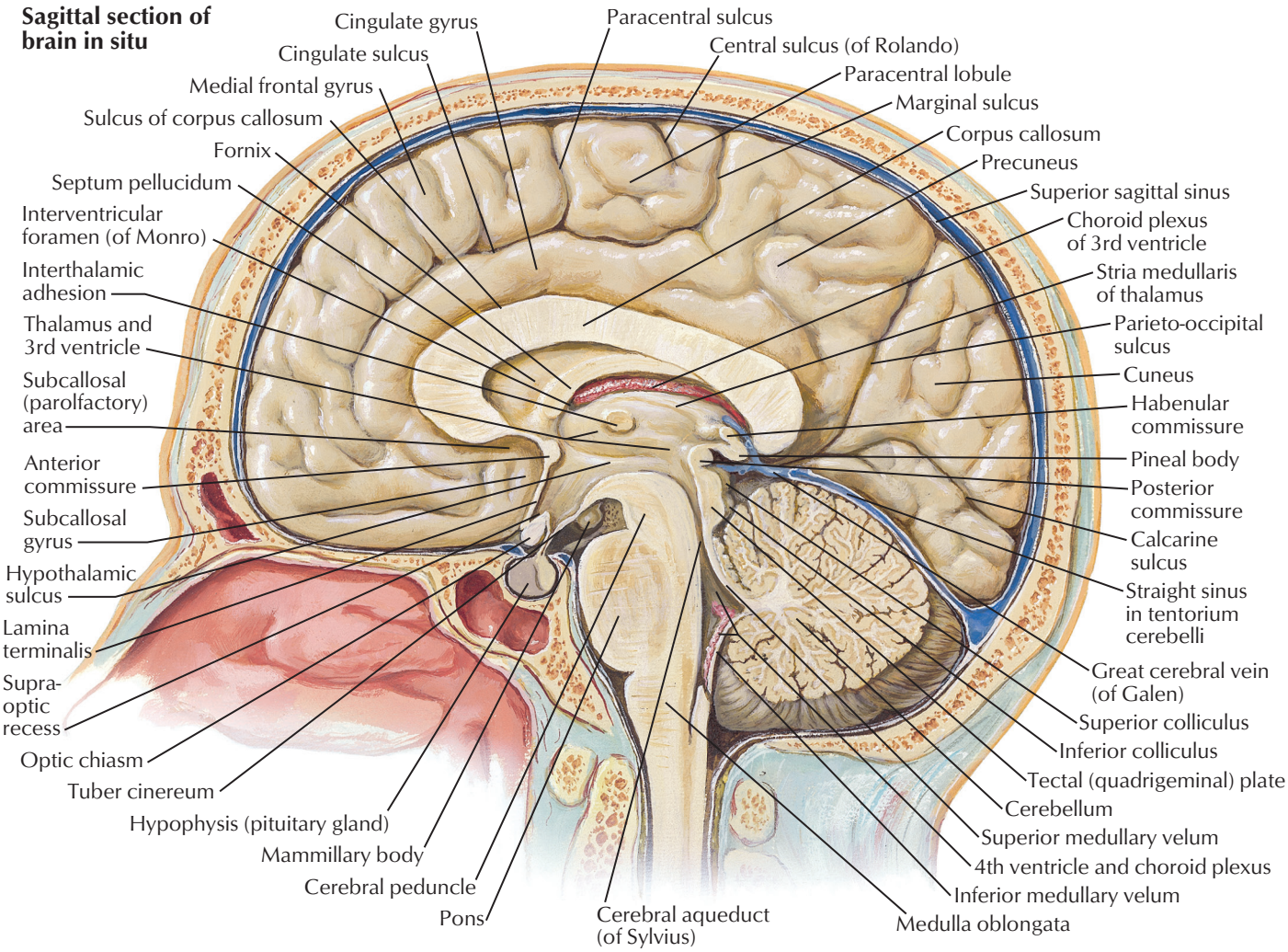
Coronal section through cavernous sinus: posterior view


Central sulcus (of Rolando)
Postcentral gyrus
Precentral gyrus
Postcentral sulcus
Precentral sulcus
Superior parietal lobule
Superior frontal gyrus
Intraparietal sulcus
Superior frontal sulcus
Inferior parietal lobule
Middle frontal gyrus
Supramarginal gyrus
Inferior frontal sulcus
Angular gyrus
Inferior frontal gyrus
Opercular part
Triangular part
Orbital part
Parieto-occipital sulcus
Frontal pole
Occipital pole
Calcarine sulcus
Lunate sulcus (inconstant)
Lateral sulcus (of Sylvius)
Anterior ramus
Ascending ramus
Posterior ramus
Transverse occipital sulcus
Preoccipital notch
Temporal pole
Superior temporal gyrus
Superior temporal sulcus
Inferior temporal gyrus
Middle temporal gyrus
Inferior temporal sulcus

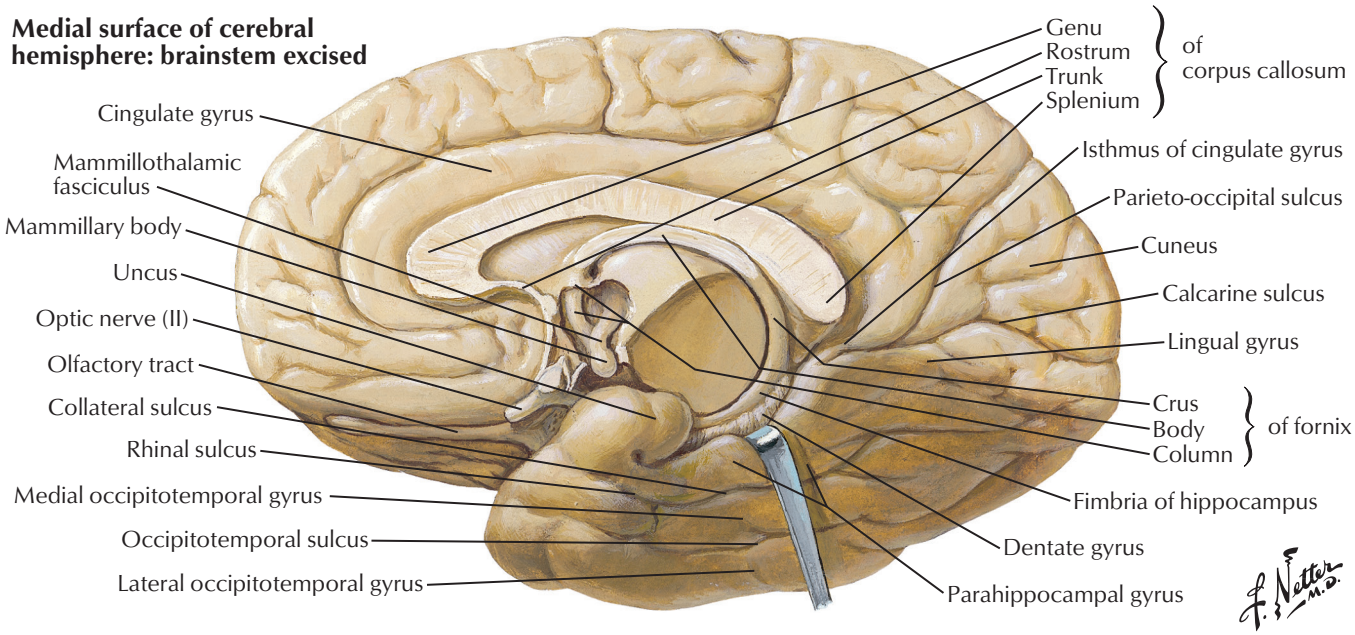

Frontal lobe
Parietal lobe
Temporal lobe
Occipital lobe


Parietal operculum
Frontal operculum
Orbital operculum
Insula (island of Reil)
Short gyri
Central sulcus
Limen
Long gyrus
Circular sulcus
Temporal operculum

Sagittal section of brain in situ

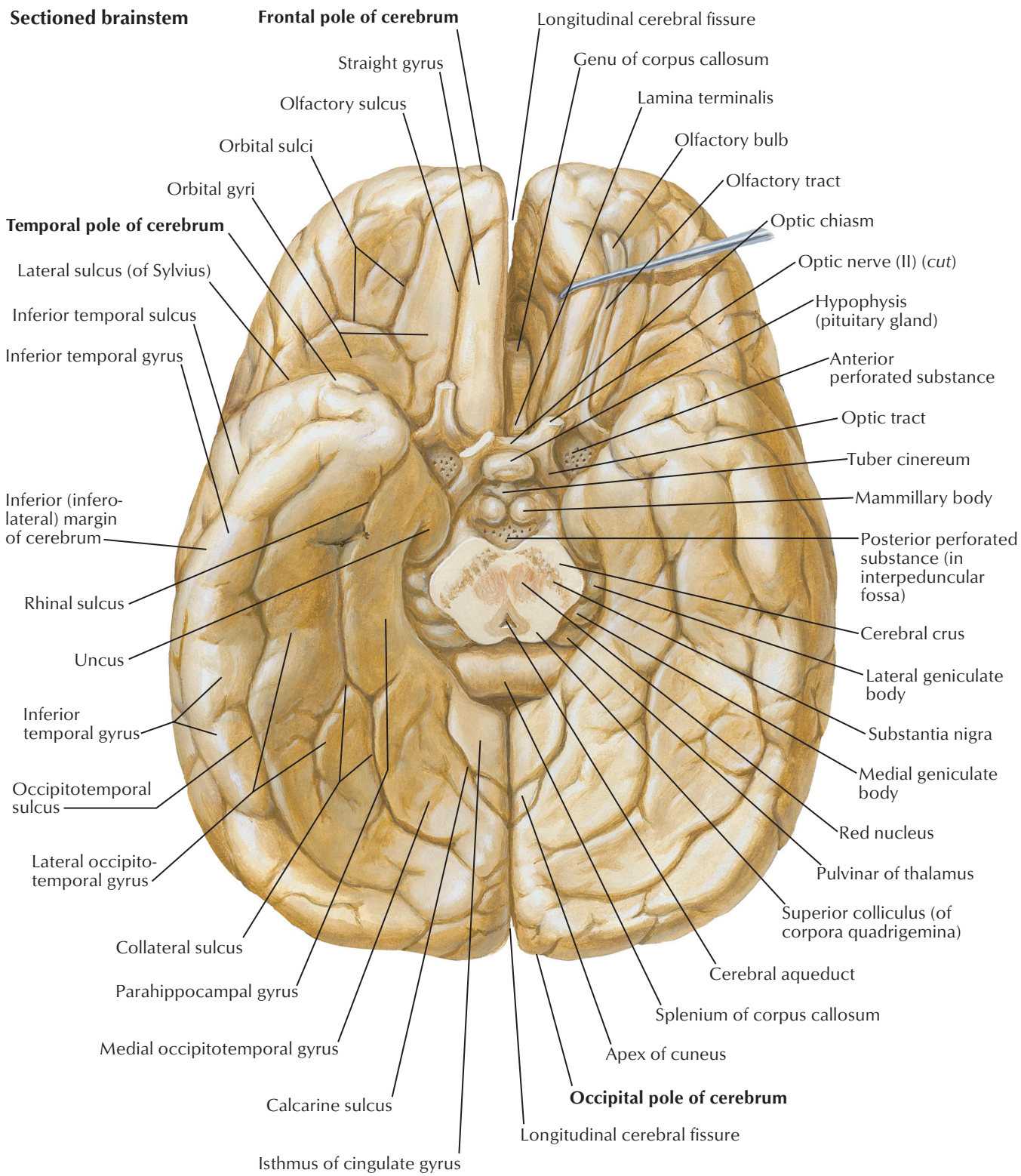


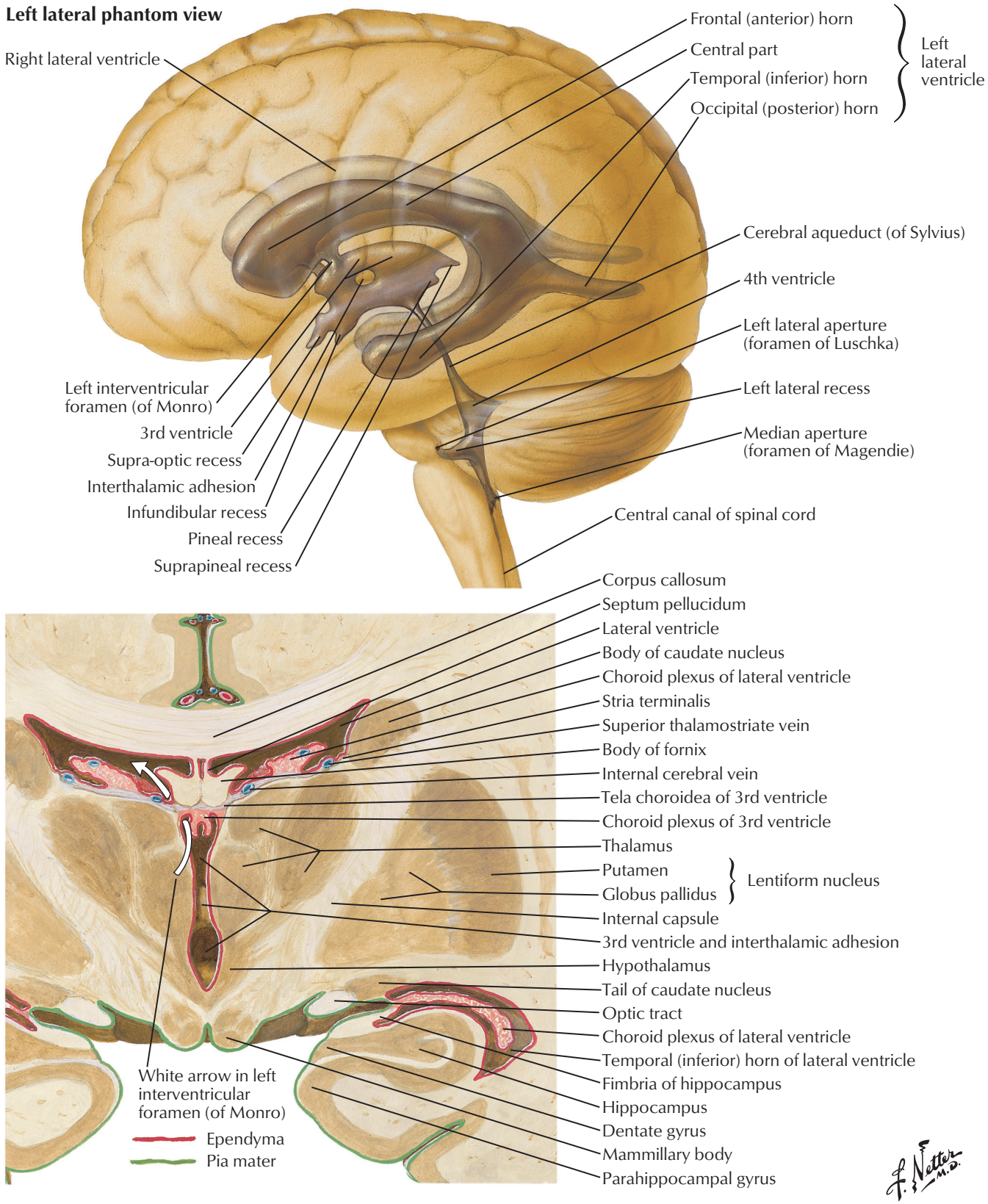
Medial surface of cerebral hemisphere: brainstem excised



Cerebrum: Inferior View

See also Plate 148

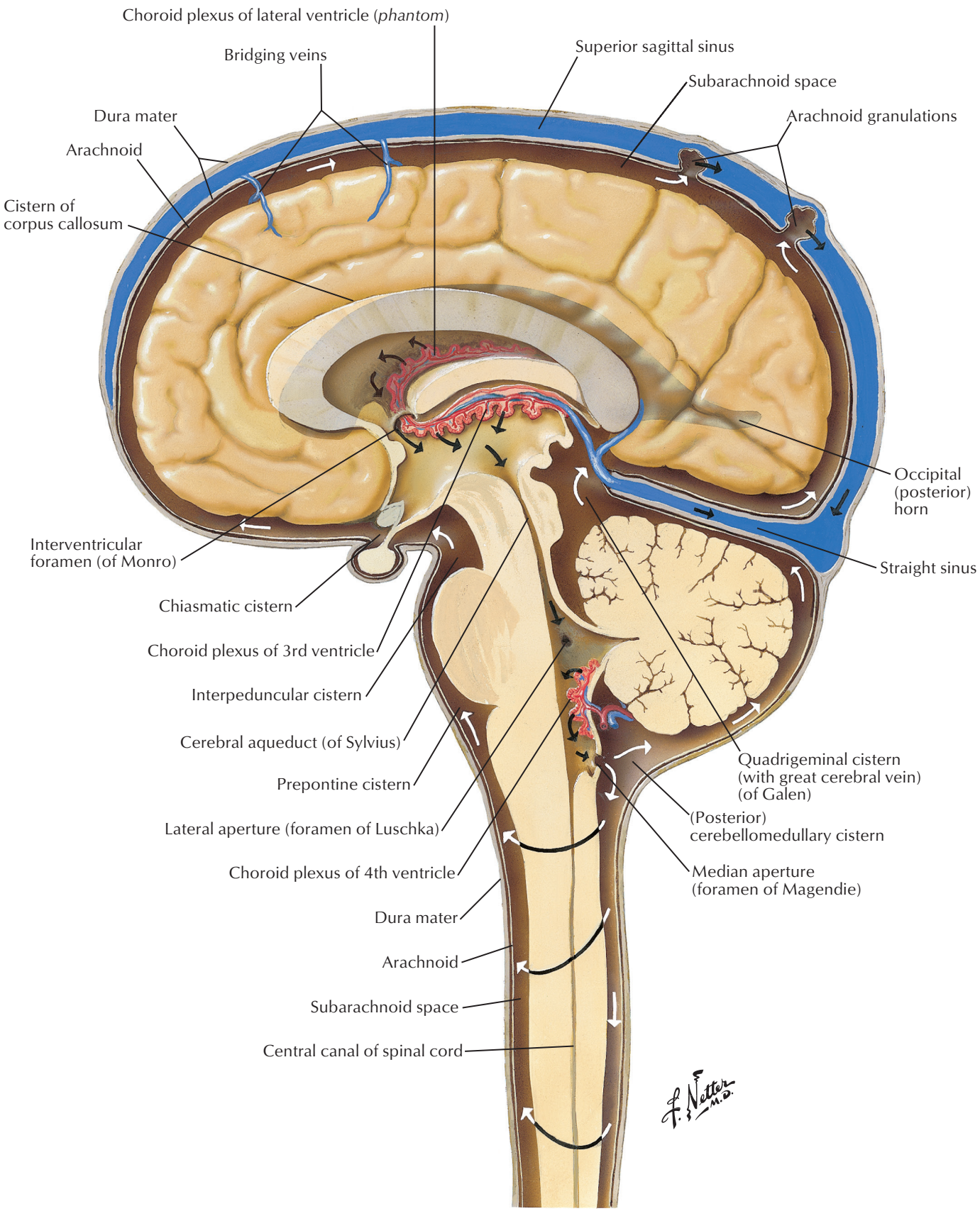




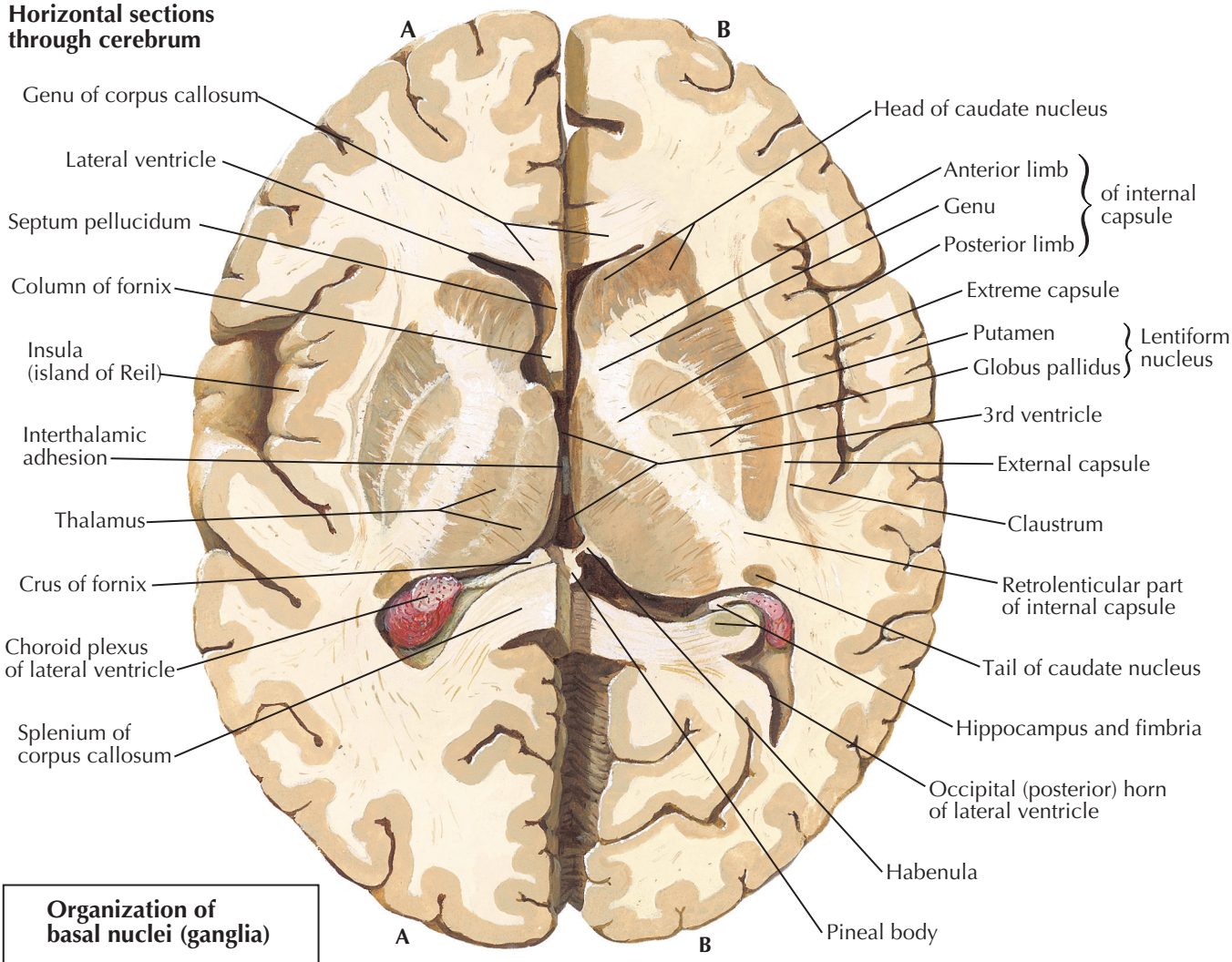
Coronal section of brain: posterior view

Circulation of Cerebrospinal Fluid

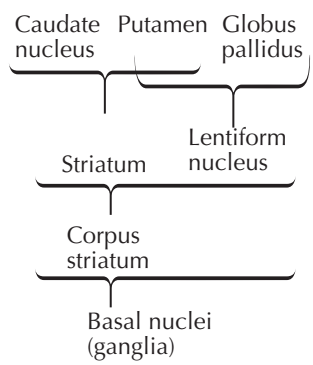
See also Plates 109, 147

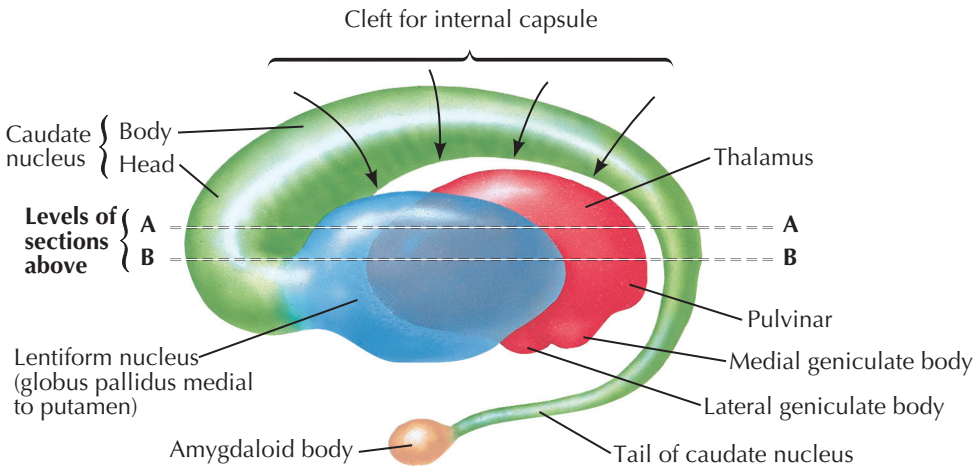


Horizontal sections through cerebrum

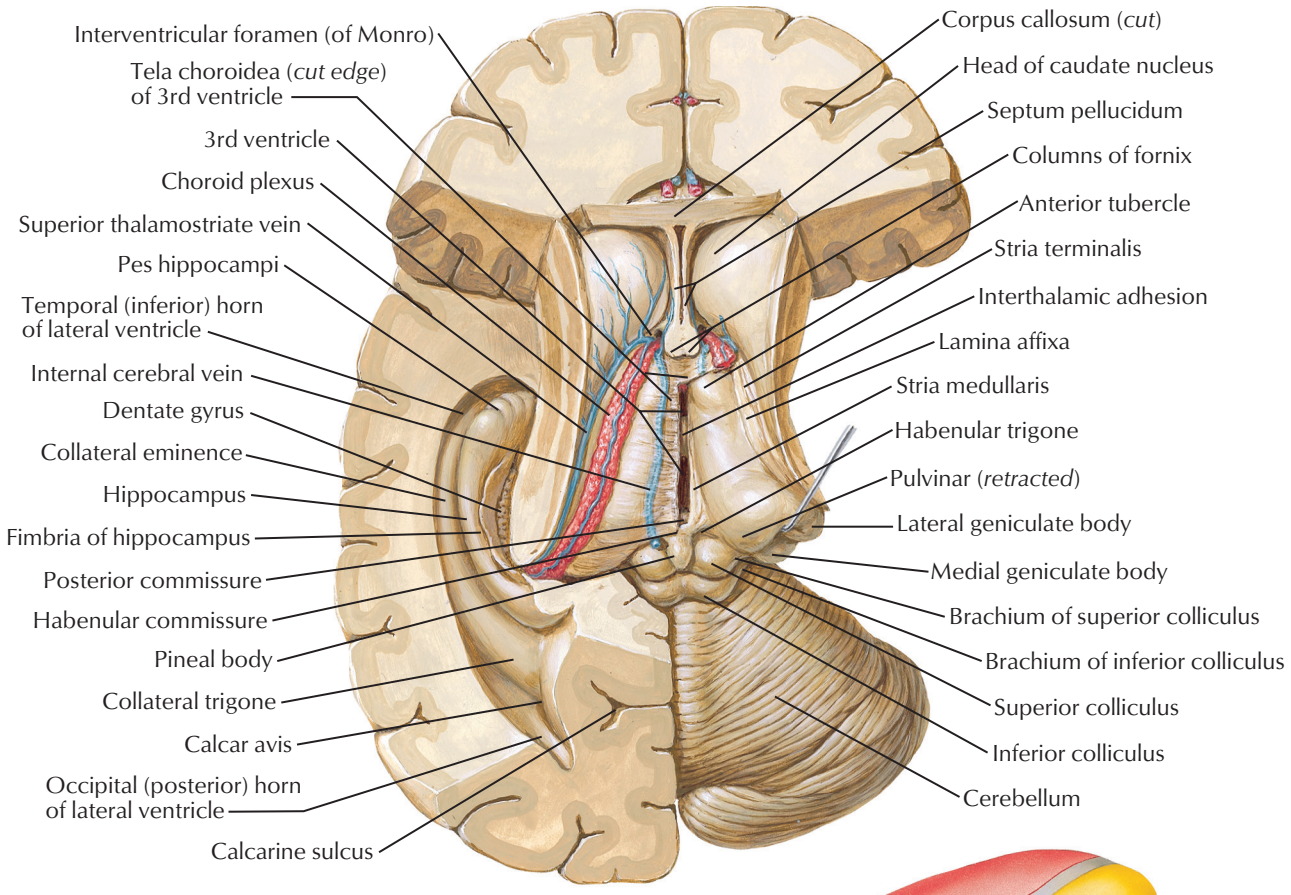


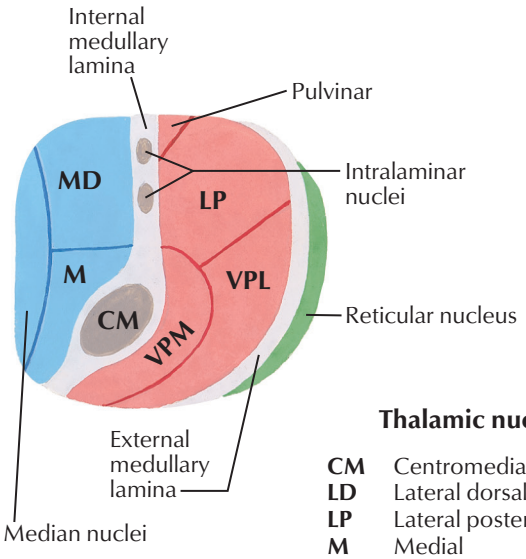
Organization of basal nuclei (ganglia)





Interrelationship of thalamus, lentiform nucleus, caudate nucleus, and amygdaloid body (schema): left lateral view

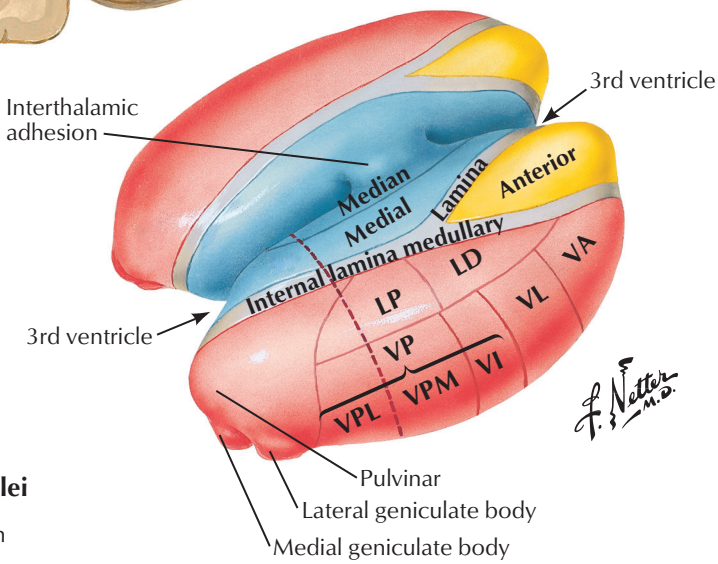




Schematic section through thalamus
(at level of broken line shown in figure at right)

Thalamic nuclei

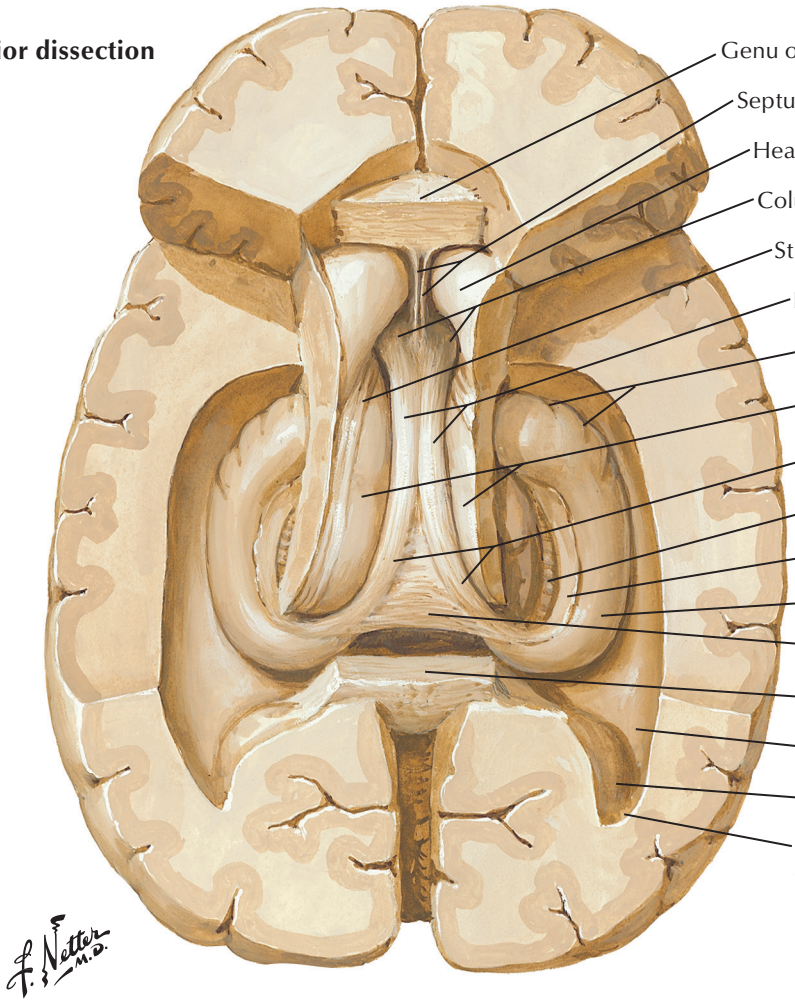
CM	Centromedian
LD	Lateral dorsal
LP	Lateral posterior
M	Medial
MD	Medial dorsal
VA	Ventral anterior
VI	Ventral intermedial
VL	Ventral lateral
VP	Ventral posterior
VPL	Ventral posterolateral
VPM	Ventral posteromedial

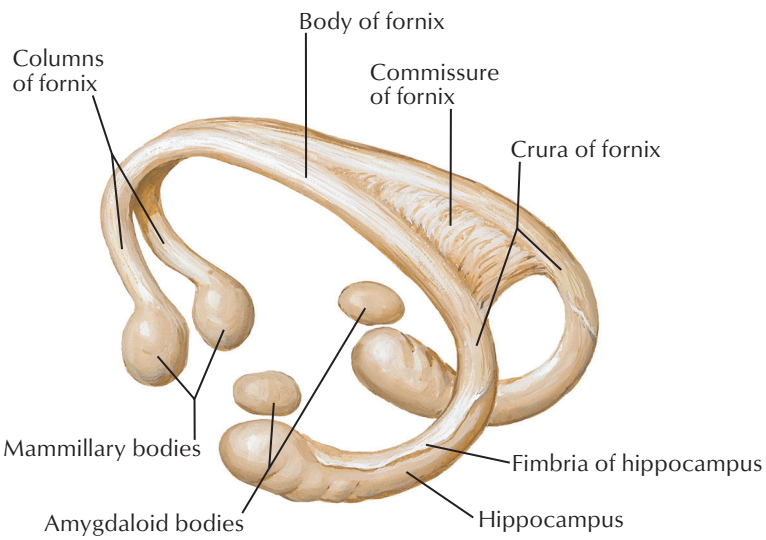


Schematic representation of thalamus
(external medullary lamina and reticular nuclei removed)

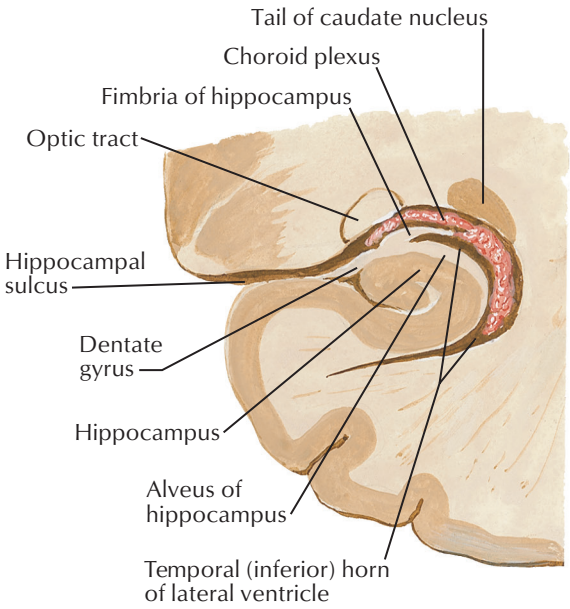
Lateral nuclei
Medial nuclei
Anterior nuclei

Superior dissection

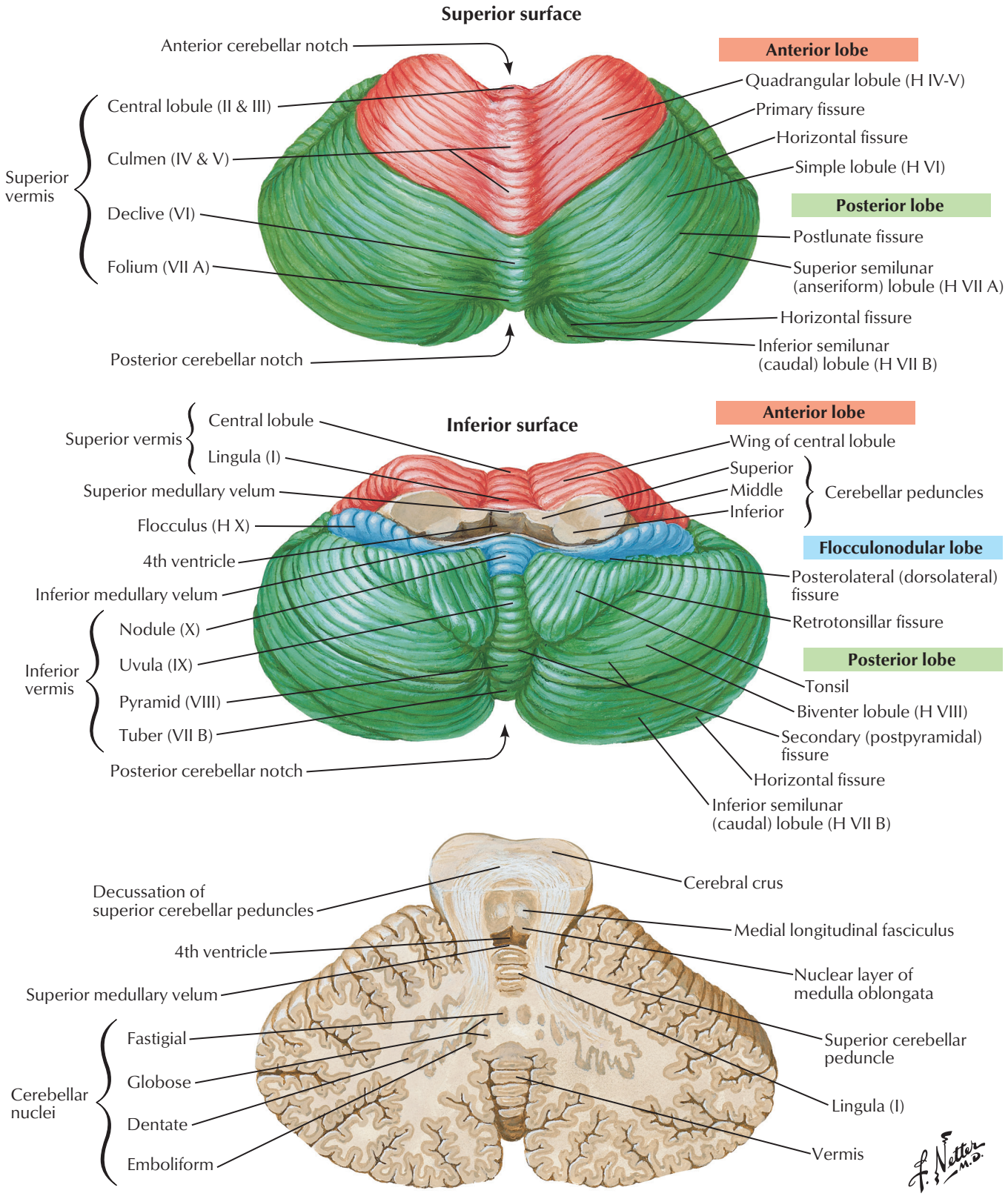




Fornix: schema

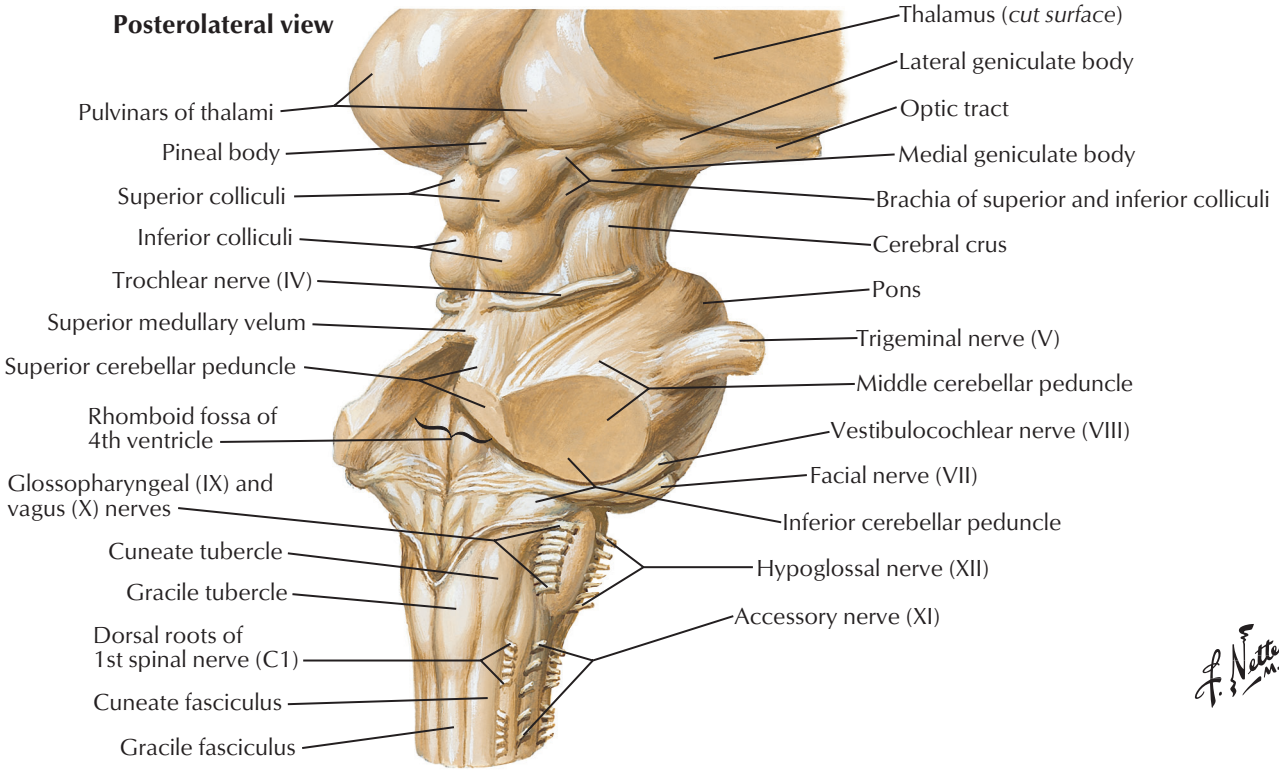


Coronal section: posterior view

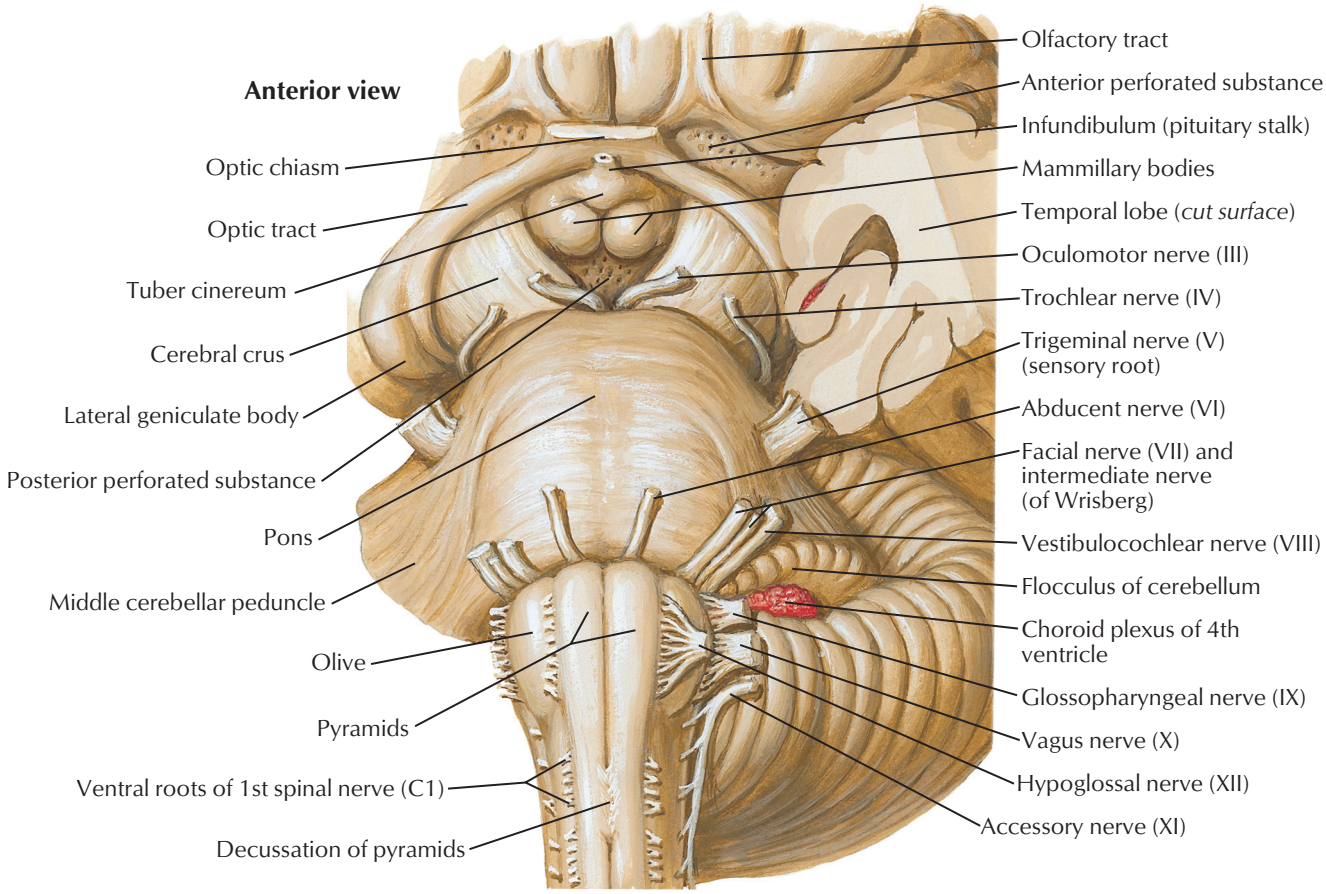


Section in plane of superior cerebellar peduncle

Posterolateral view

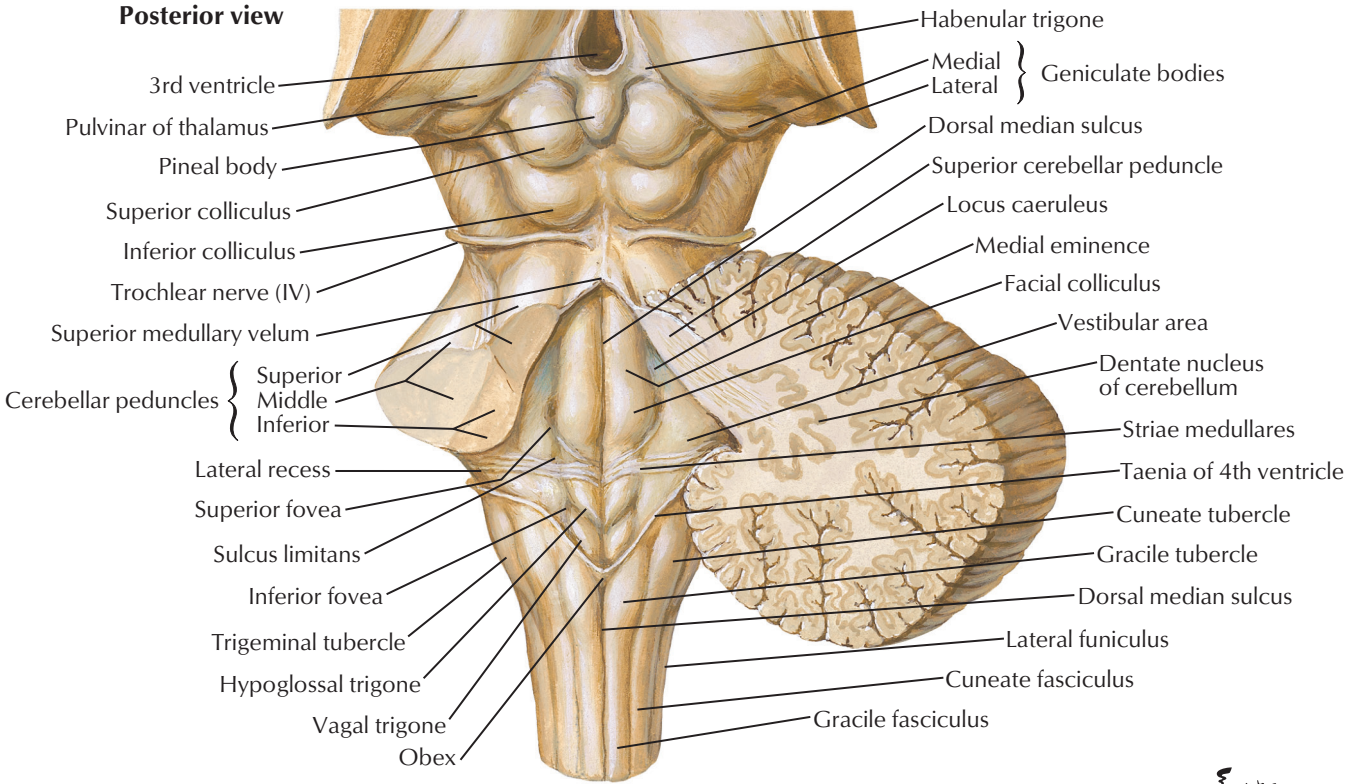


Anterior view

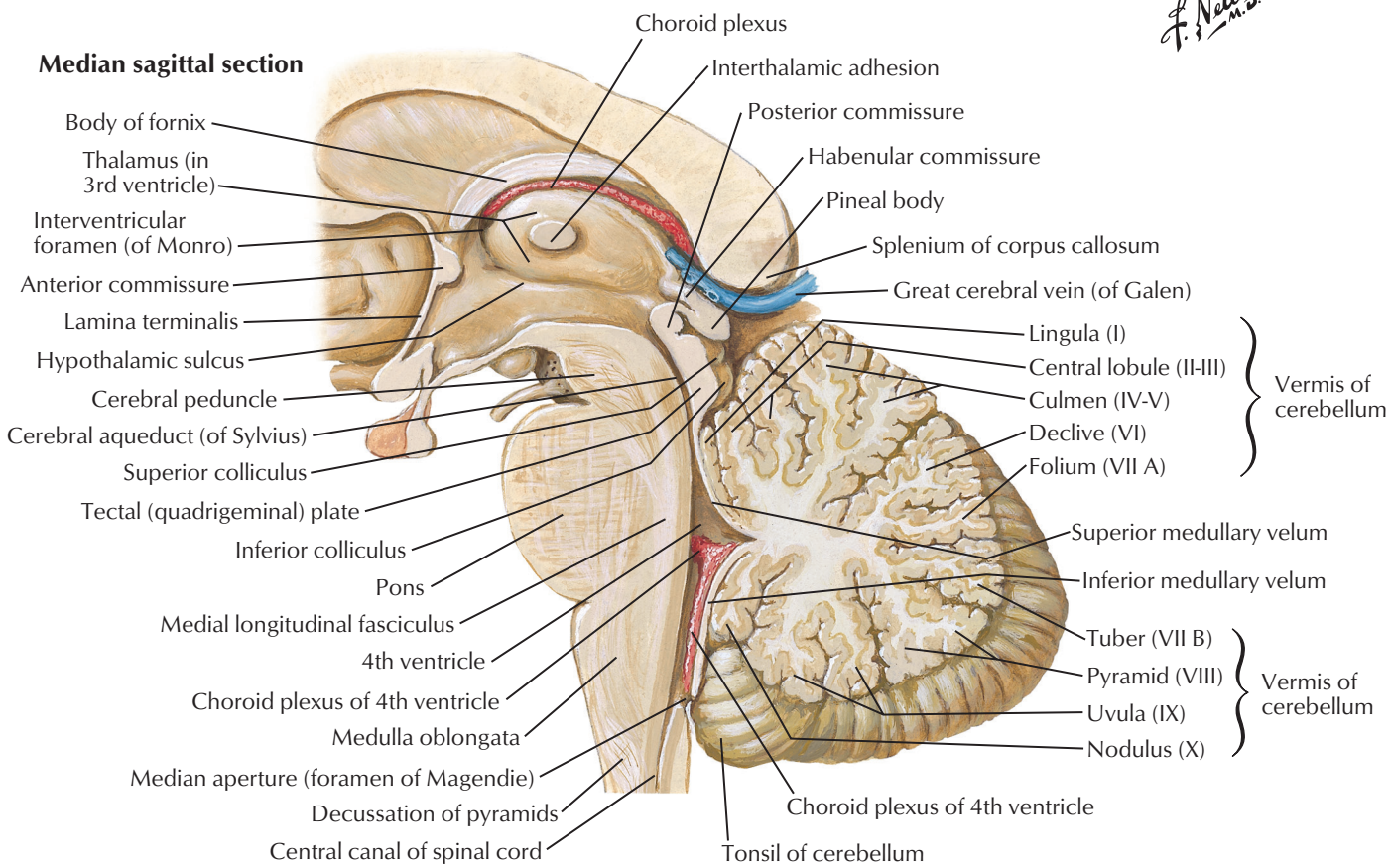


See also Plate 114

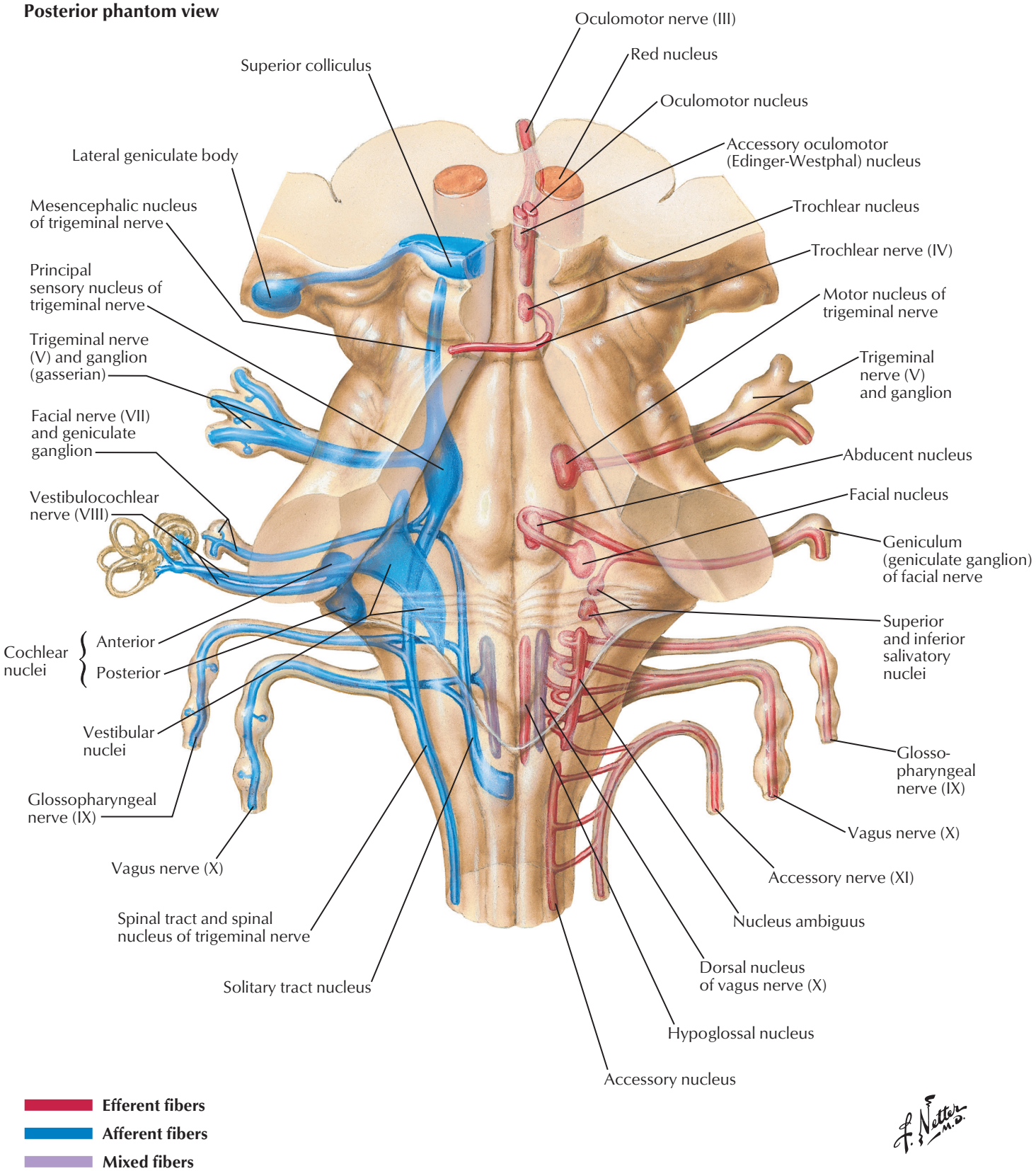
Posterior view



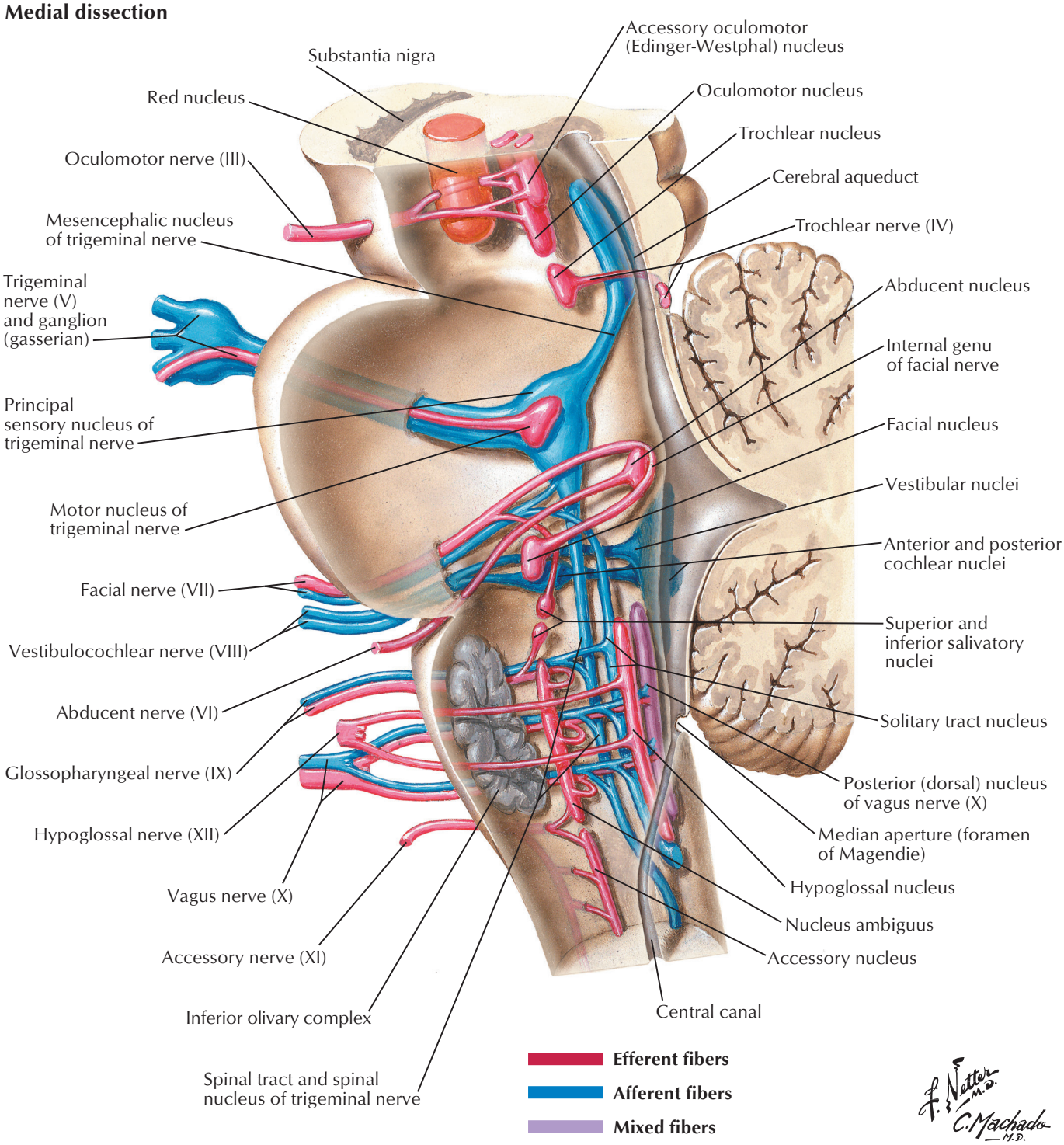
Median sagittal section

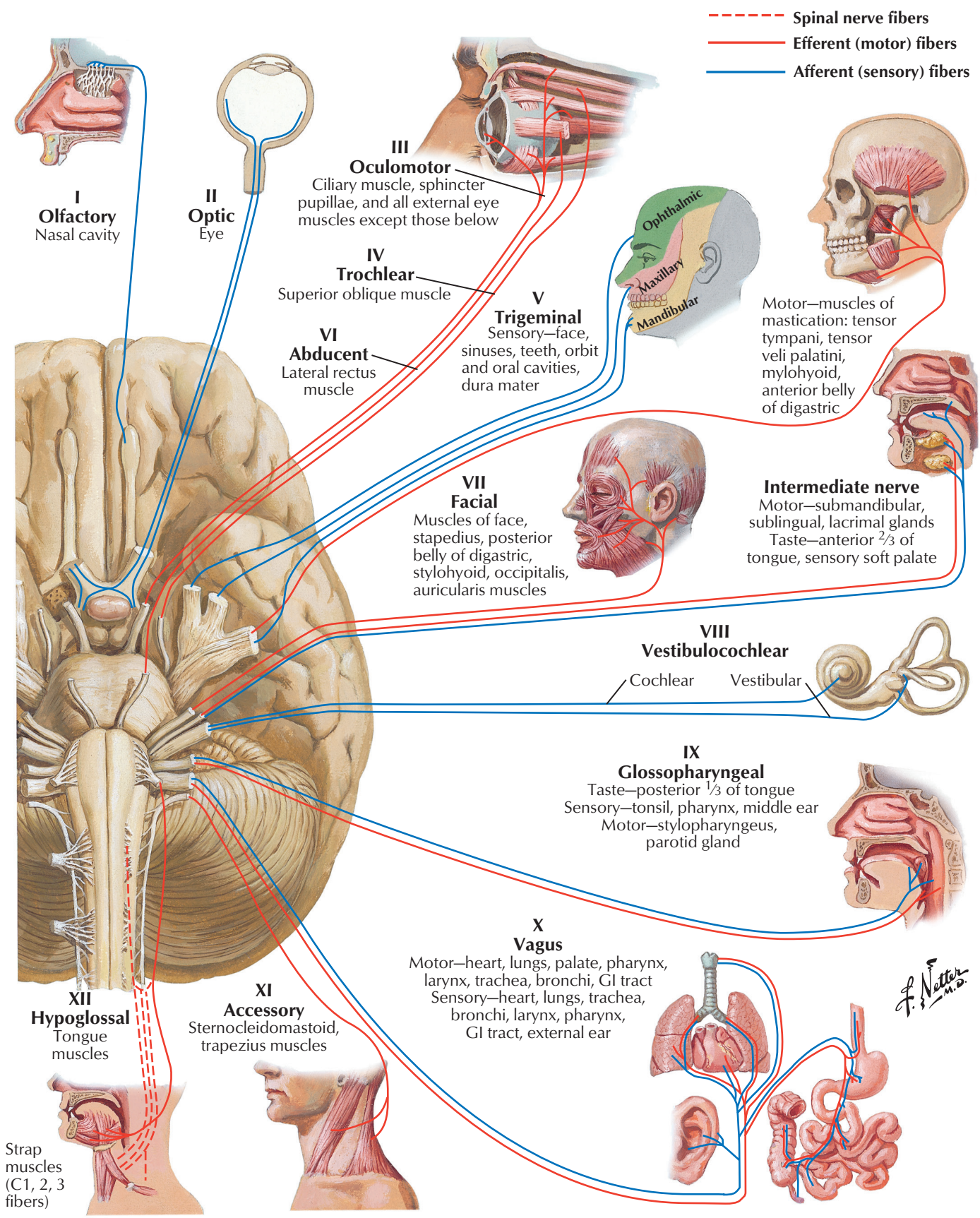


Posterior phantom view



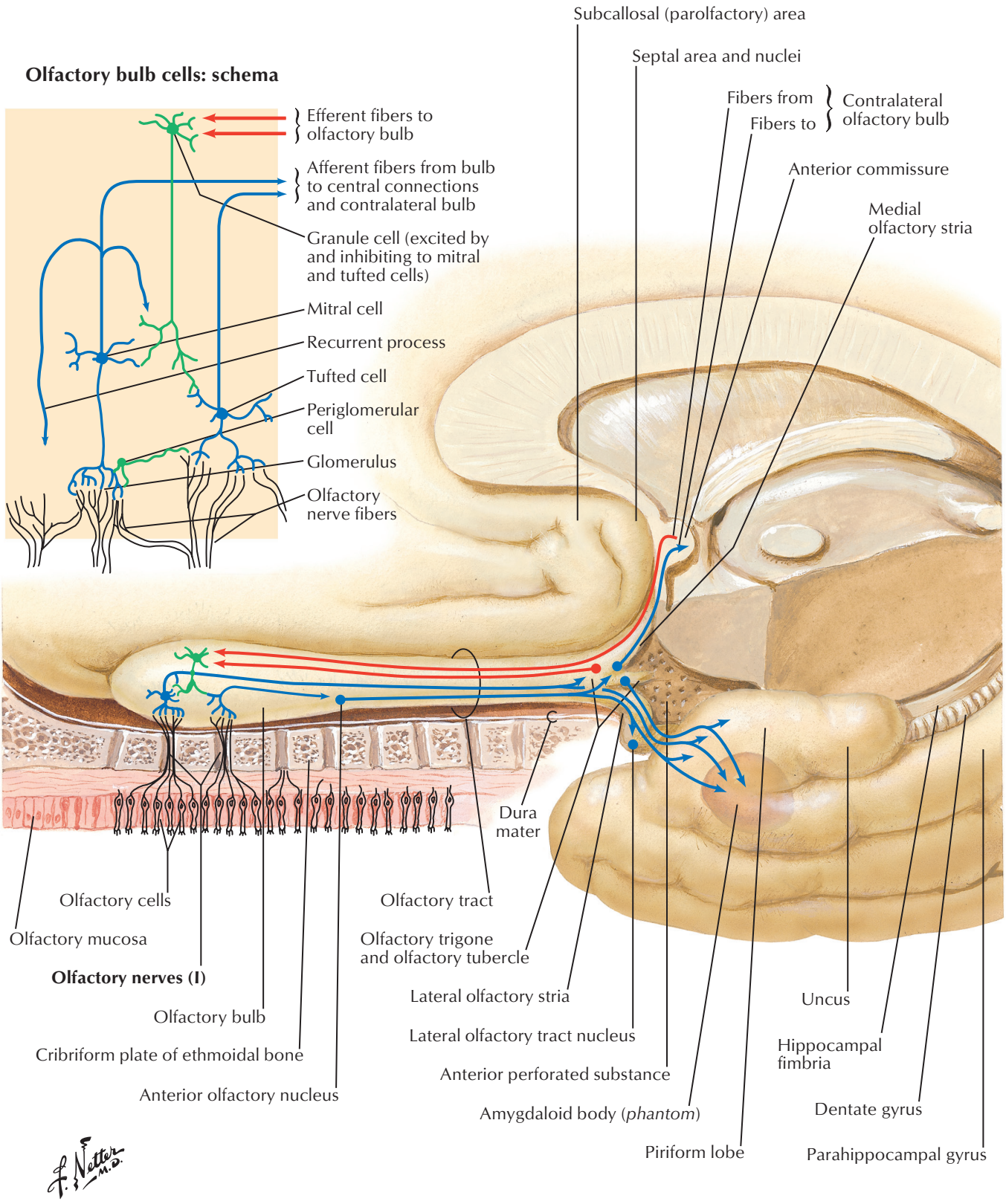
Medial dissection




Spinal nerve fibers
Efferent (motor) fibers
Afferent (sensory) fibers
I
Olfactory
Nasal cavity
II
Optic
Eye
III
Oculomotor
Ciliary muscle, sphincter pupillae, and all external eye muscles except those below
IV
Trochlear
Superior oblique muscle
VI
Abducent
Lateral rectus muscle
V
Trigeminal
Sensory—face, sinuses, teeth, orbit and oral cavities, dura mater
Ophthalmic
Maxillary
Mandibular
Motor—muscles of mastication: tensor tympani, tensor veli palatini, mylohyoid, anterior belly of digastric
VII
Facial
Muscles of face, stapedius, posterior belly of digastric, stylohyoid, occipitalis, auricularis muscles
Intermediate nerve
Motor—submandibular, sublingual, lacrimal glands
Taste—anterior 2/3 of tongue, sensory soft palate
VIII
Vestibulocochlear
Cochlear
Vestibular
IX
Glossopharyngeal
Taste—posterior 1/3 of tongue
Sensory—tonsil, pharynx, middle ear
Motor—stylopharyngeus, parotid gland
X
Vagus
Motor—heart, lungs, palate, pharynx, larynx, trachea, bronchi, GI tract
Sensory—heart, lungs, trachea, bronchi, larynx, pharynx, GI tract, external ear
XI
Accessory
Sternocleidomastoid, trapezius muscles
XII
Hypoglossal
Tongue muscles
Strap muscles (C1, 2, 3 fibers)
F. Netter M.D.

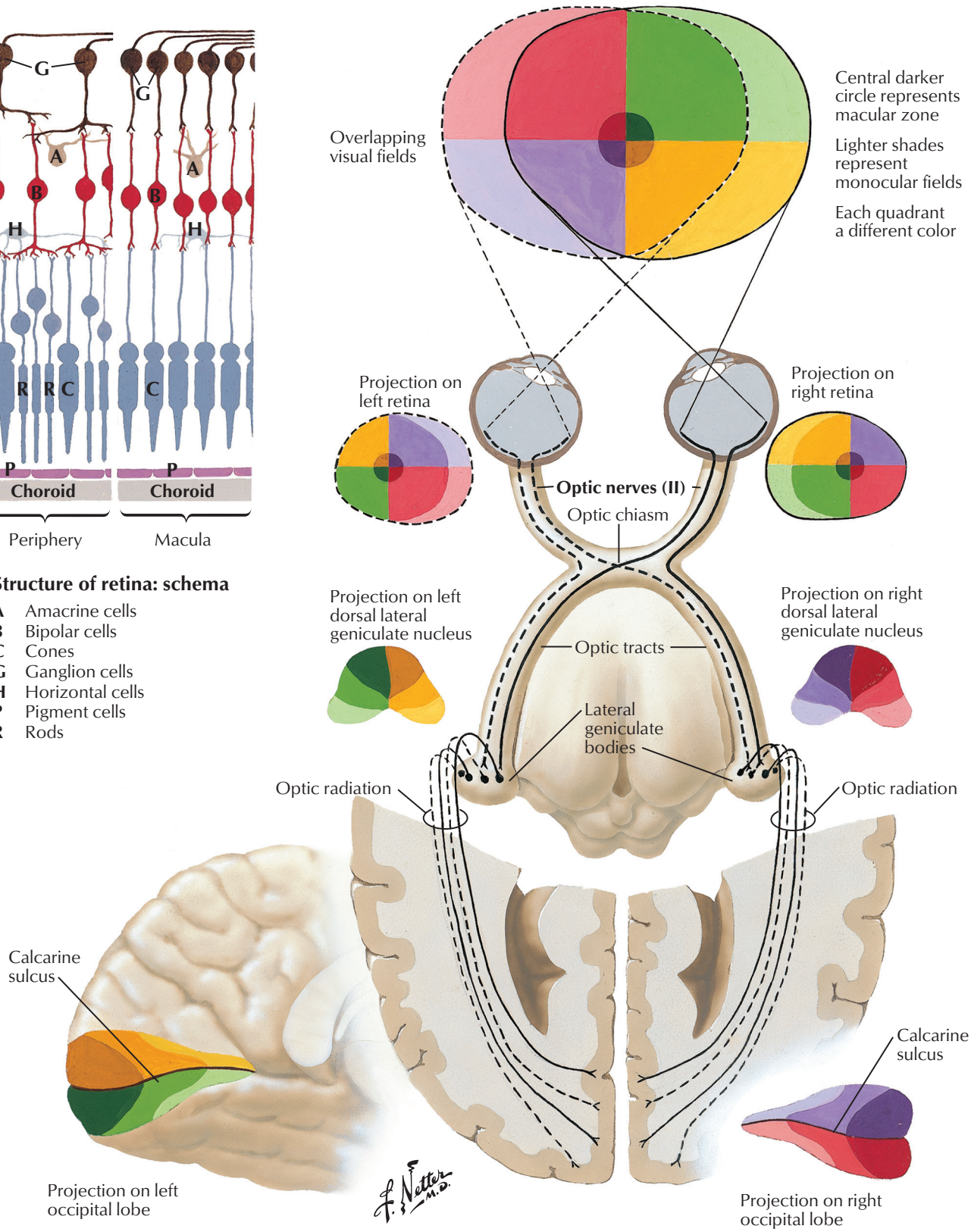
Olfactory Nerve (I): Schema

See also Plate 39



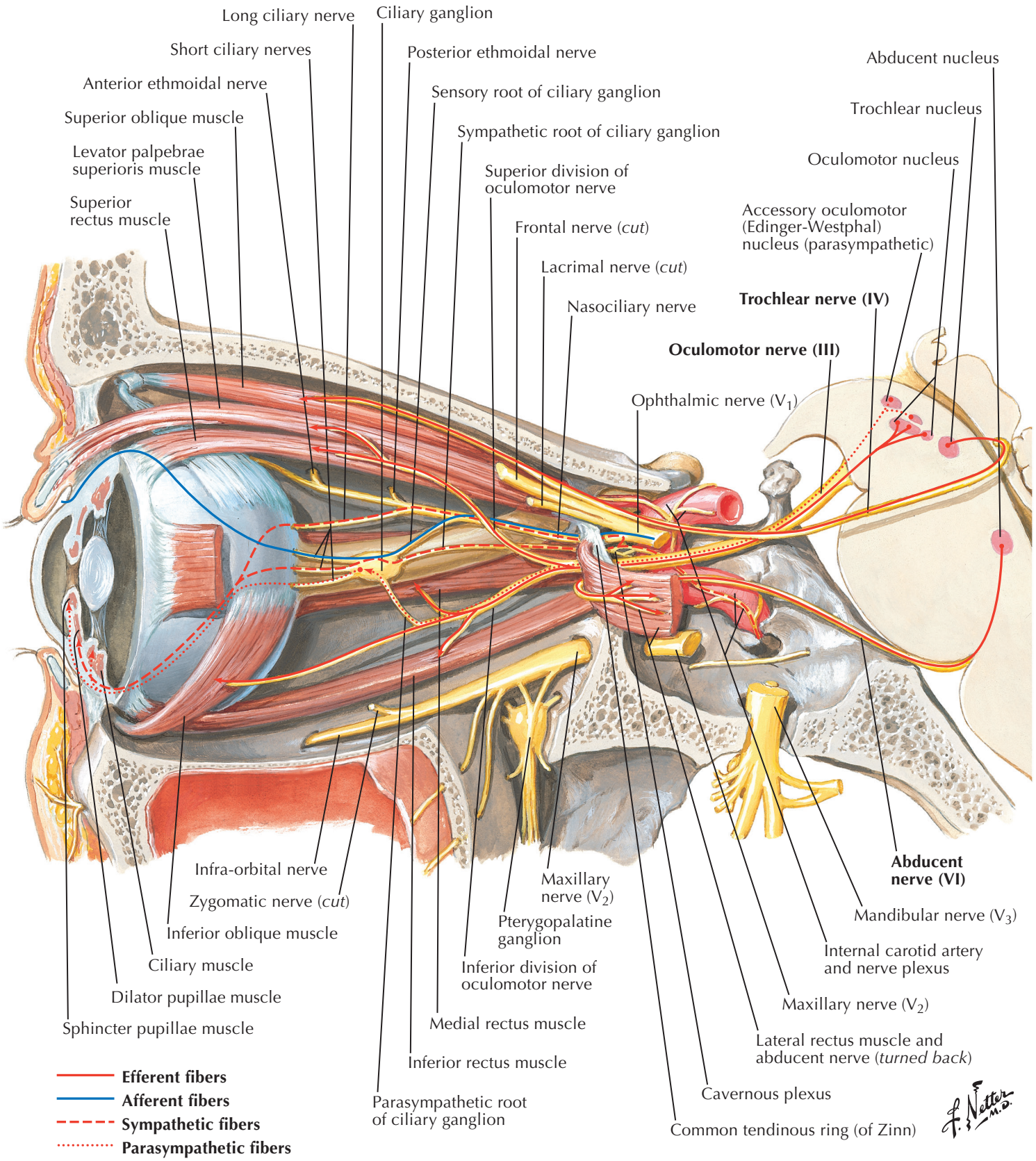
Structure of retina: schema

- **A** Amacrine cells
- **B** Bipolar cells
- **C** Cones
- **G** Ganglion cells
- **H** Horizontal cells
- **P** Pigment cells
- **R** Rods



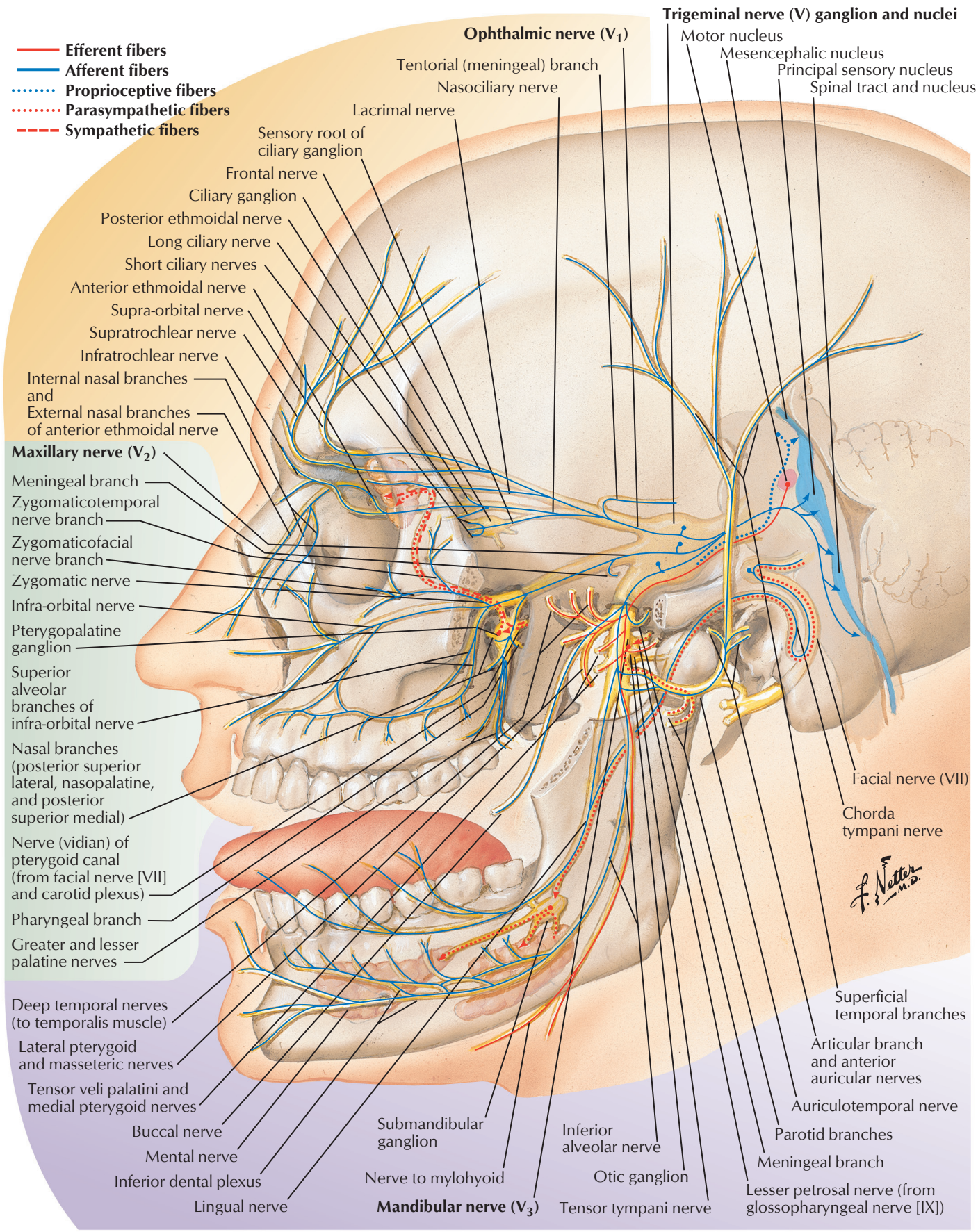
Oculomotor (III), Trochlear (IV), and Abducent (VI) Nerves: Schema

See also Plates 88, 133



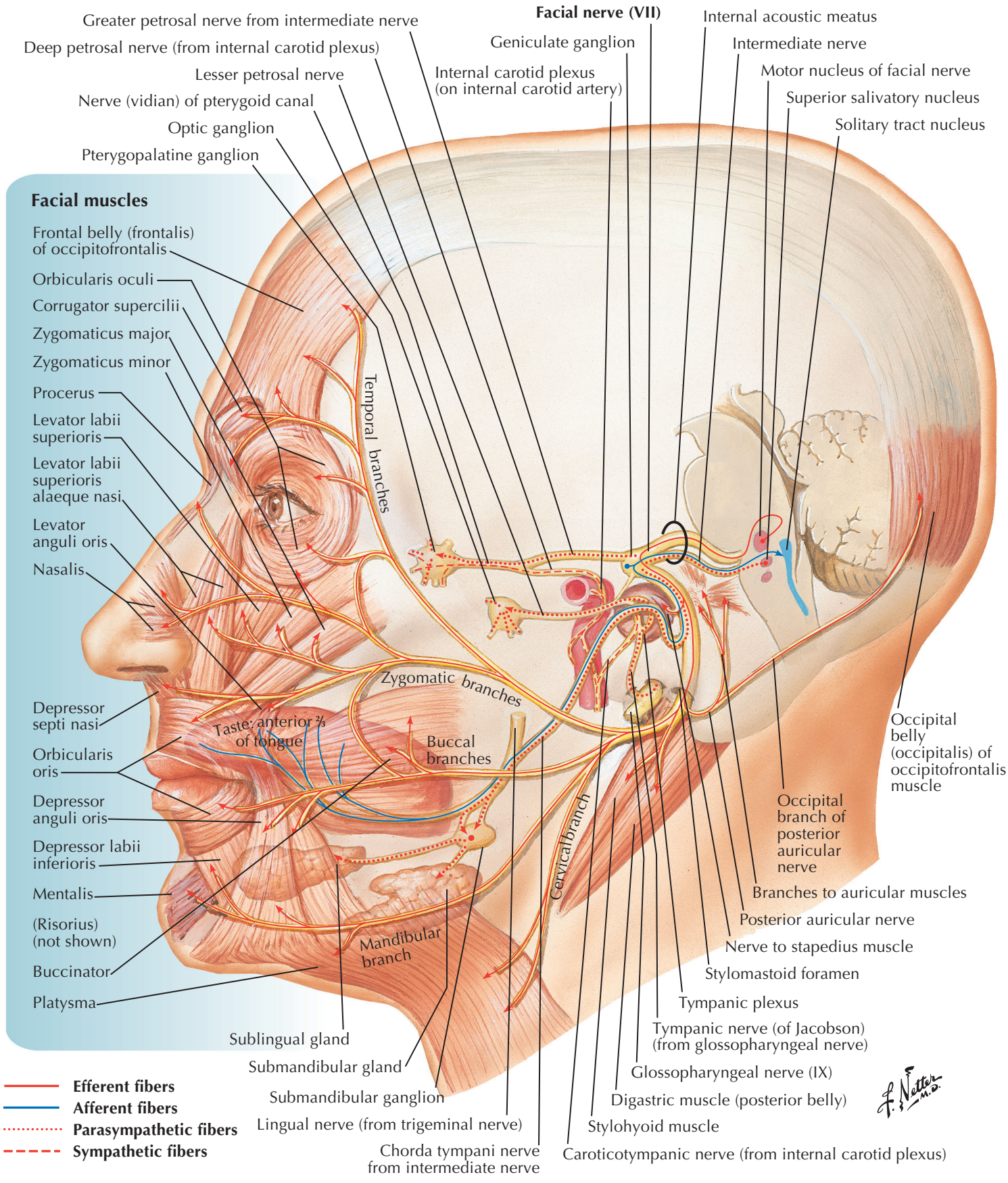
Trigeminal Nerve (V): Schema

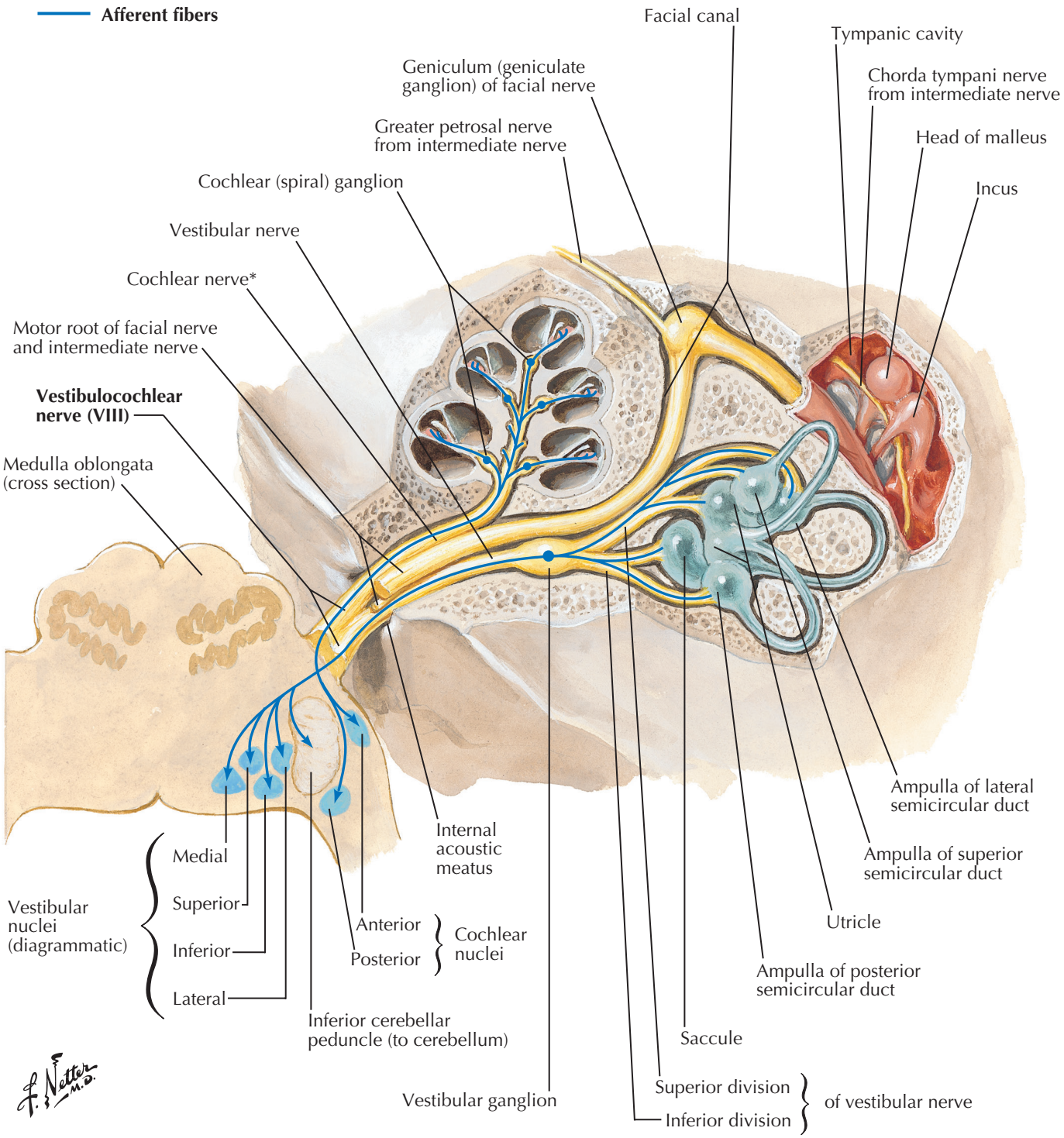
See also Plates 2, 50, 52



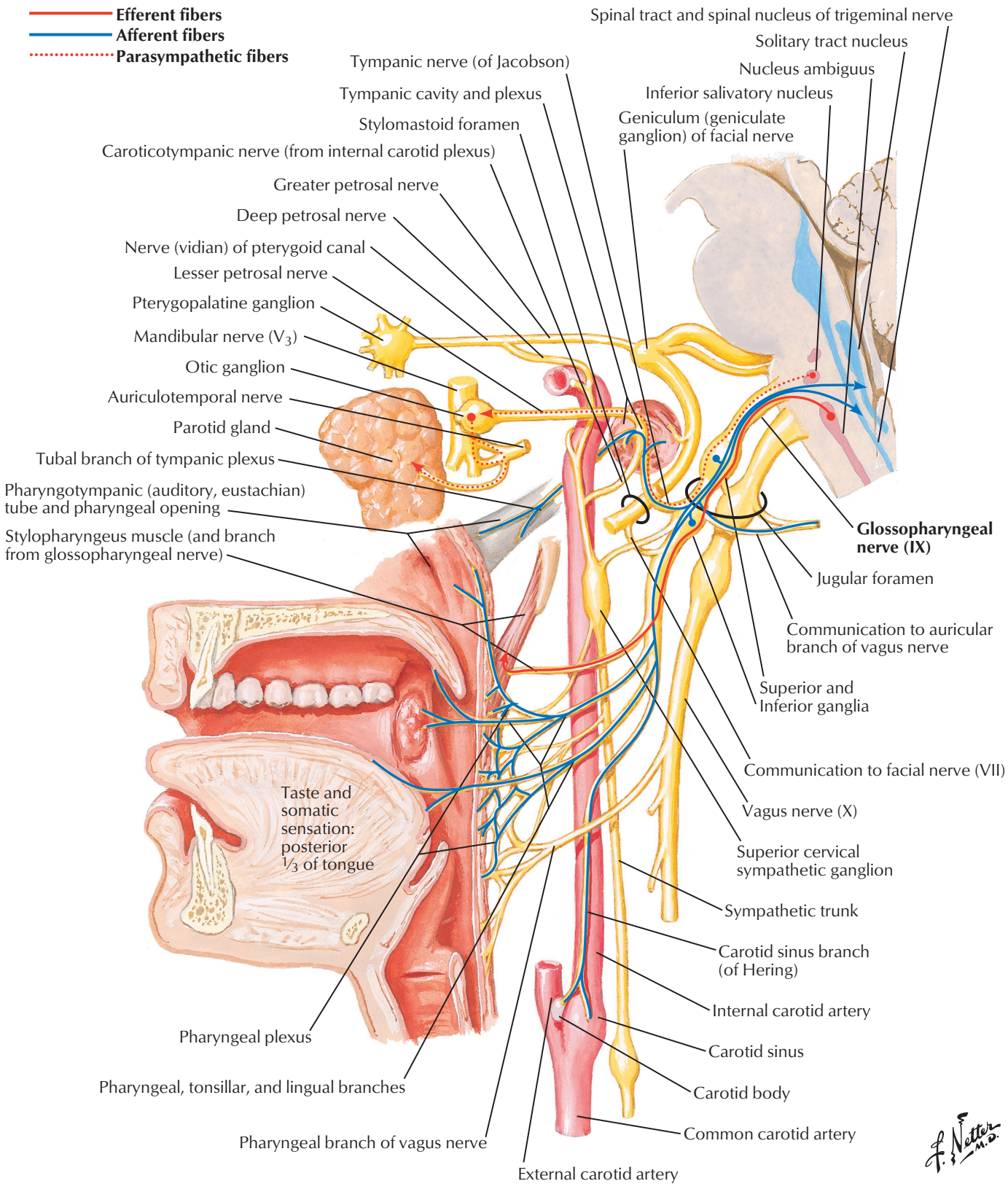
Facial Nerve (VII): Schema

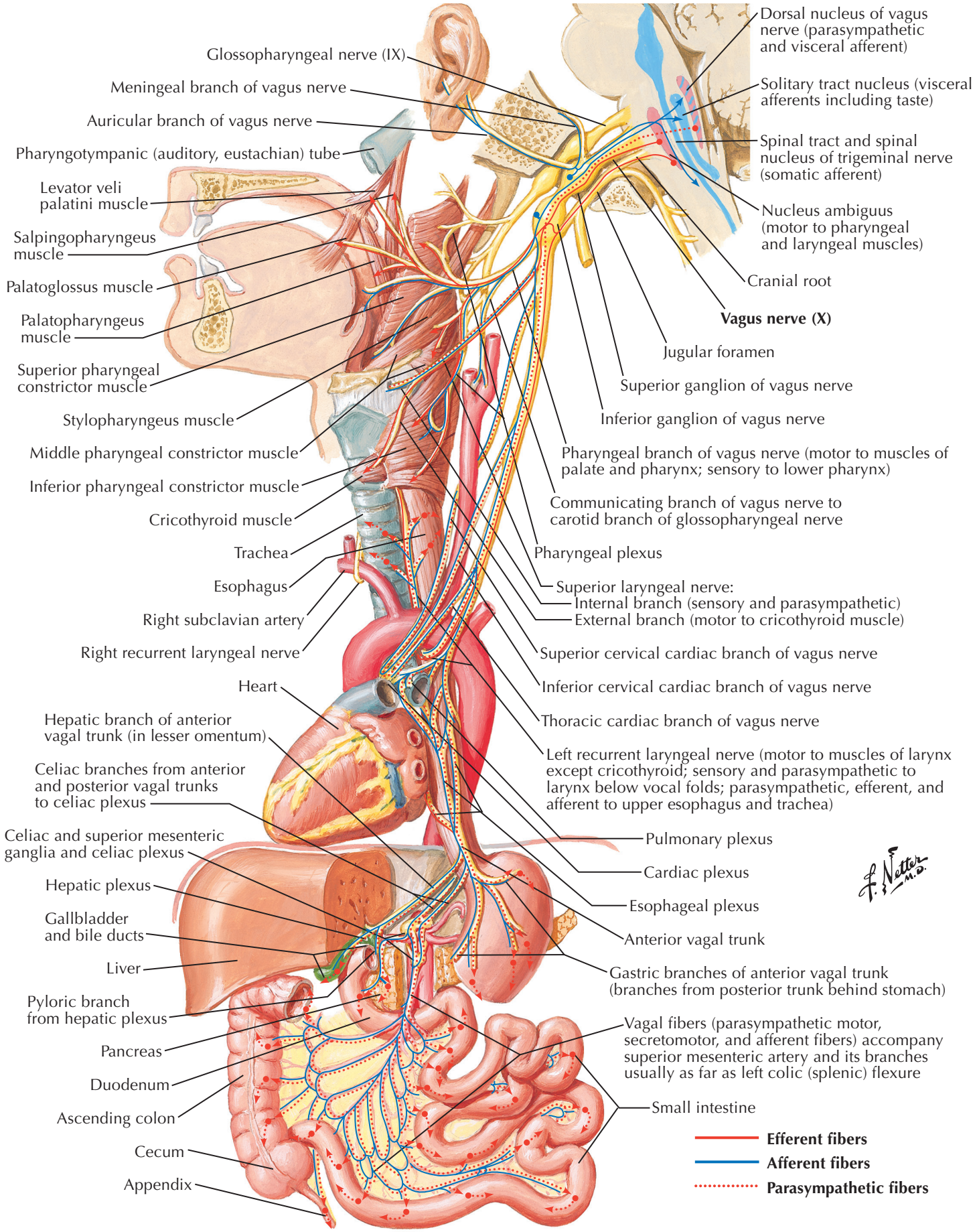
See also Plate 24





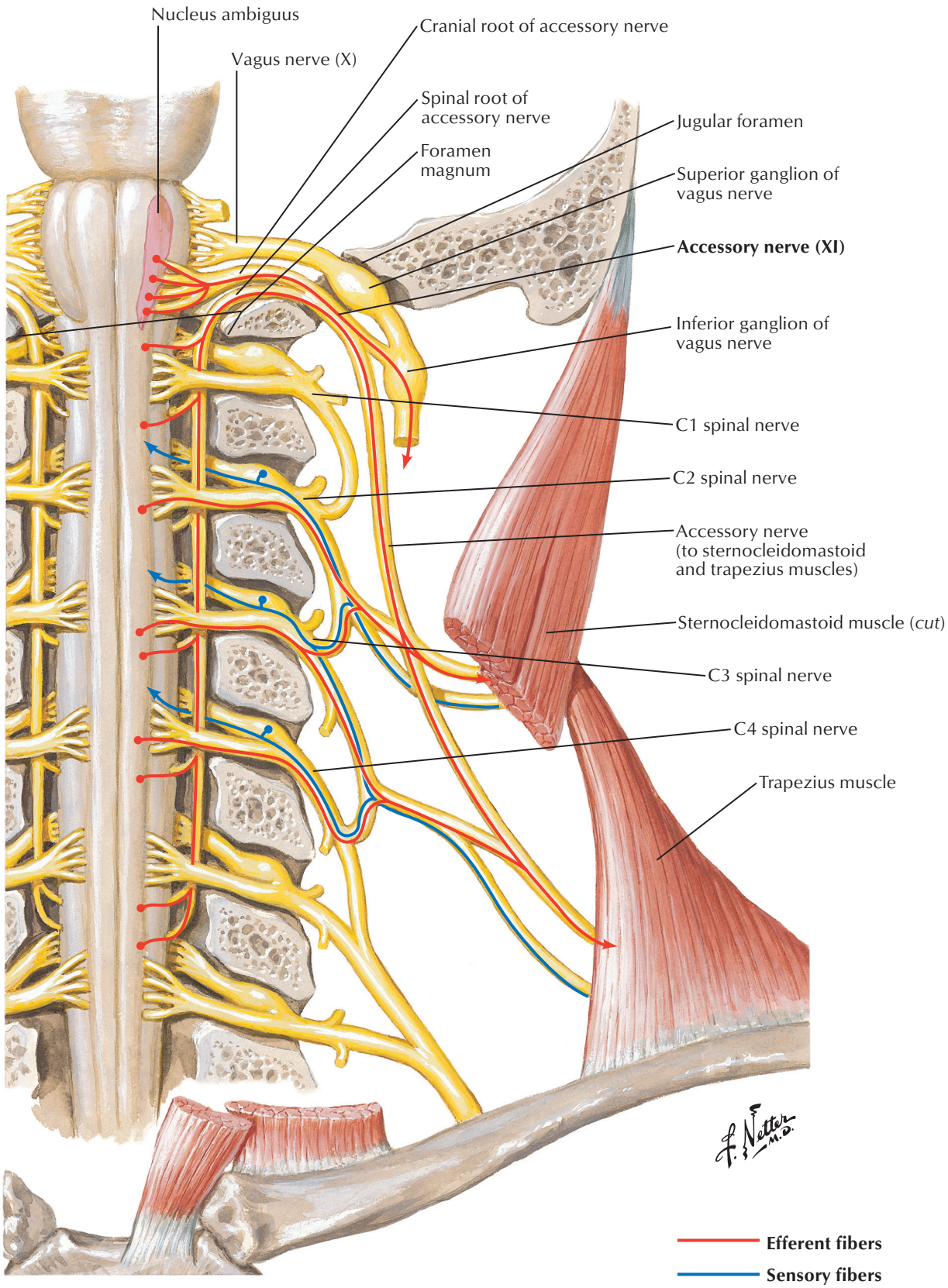
*Note: The cochlear nerve also contains efferent fibers to the sensory epithelium. These fibers are derived from the vestibular nerve while in the internal auditory meatus.


Efferent fibers
Afferent fibers
Parasympathetic fibers
Spinal tract and spinal nucleus of trigeminal nerve
Solitary tract nucleus
Nucleus ambiguus
Inferior salivatory nucleus
Geniculum (geniculate ganglion) of facial nerve
Tympanic nerve (of Jacobson)
Tympanic cavity and plexus
Stylomastoid foramen
Caroticotympanic nerve (from internal carotid plexus)
Greater petrosal nerve
Deep petrosal nerve
Nerve (vidian) of pterygoid canal
Lesser petrosal nerve
Pterygopalatine ganglion
Mandibular nerve (V3)
Otic ganglion
Auriculotemporal nerve
Parotid gland
Tubal branch of tympanic plexus
Pharyngotympanic (auditory, eustachian) tube and pharyngeal opening
Stylopharyngeus muscle (and branch from glossopharyngeal nerve)
Glossopharyngeal nerve (IX)
Jugular foramen
Communication to auricular branch of vagus nerve
Superior and Inferior ganglia
Communication to facial nerve (VII)
Vagus nerve (X)
Superior cervical sympathetic ganglion
Sympathetic trunk
Carotid sinus branch (of Hering)
Internal carotid artery
Carotid sinus
Carotid body
Common carotid artery
Taste and somatic sensation: posterior 1/3 of tongue
Pharyngeal plexus
Pharyngeal, tonsillar, and lingual branches
Pharyngeal branch of vagus nerve
External carotid artery


Glossopharyngeal nerve (IX)
Meningeal branch of vagus nerve
Auricular branch of vagus nerve
Pharyngotympanic (auditory, eustachian) tube
Levator veli palatini muscle
Salpingopharyngeus muscle
Palatoglossus muscle
Palatopharyngeus muscle
Superior pharyngeal constrictor muscle
Stylopharyngeus muscle
Middle pharyngeal constrictor muscle
Inferior pharyngeal constrictor muscle
Cricothyroid muscle
Trachea
Esophagus
Right subclavian artery
Right recurrent laryngeal nerve
Heart
Hepatic branch of anterior vagal trunk (in lesser omentum)
Celiac branches from anterior and posterior vagal trunks to celiac plexus
Celiac and superior mesenteric ganglia and celiac plexus
Hepatic plexus
Gallbladder and bile ducts
Liver
Pyloric branch from hepatic plexus
Pancreas
Duodenum
Ascending colon
Cecum
Appendix
Dorsal nucleus of vagus nerve (parasympathetic and visceral afferent)
Solitary tract nucleus (visceral afferents including taste)
Spinal tract and spinal nucleus of trigeminal nerve (somatic afferent)
Nucleus ambiguus (motor to pharyngeal and laryngeal muscles)
Cranial root
Vagus nerve (X)
Jugular foramen
Superior ganglion of vagus nerve
Inferior ganglion of vagus nerve
Pharyngeal branch of vagus nerve (motor to muscles of palate and pharynx; sensory to lower pharynx)
Communicating branch of vagus nerve to carotid branch of glossopharyngeal nerve
Pharyngeal plexus
Superior laryngeal nerve:
Internal branch (sensory and parasympathetic)
External branch (motor to cricothyroid muscle)
Superior cervical cardiac branch of vagus nerve
Inferior cervical cardiac branch of vagus nerve
Thoracic cardiac branch of vagus nerve
Left recurrent laryngeal nerve (motor to muscles of larynx except cricothyroid; sensory and parasympathetic to larynx below vocal folds; parasympathetic, efferent, and afferent to upper esophagus and trachea)
Pulmonary plexus
Cardiac plexus
Esophageal plexus
Anterior vagal trunk
Gastric branches of anterior vagal trunk (branches from posterior trunk behind stomach)
Vagal fibers (parasympathetic motor, secretomotor, and afferent fibers) accompany superior mesenteric artery and its branches usually as far as left colic (splenic) flexure
Small intestine
Efferent fibers
Afferent fibers
Parasympathetic fibers

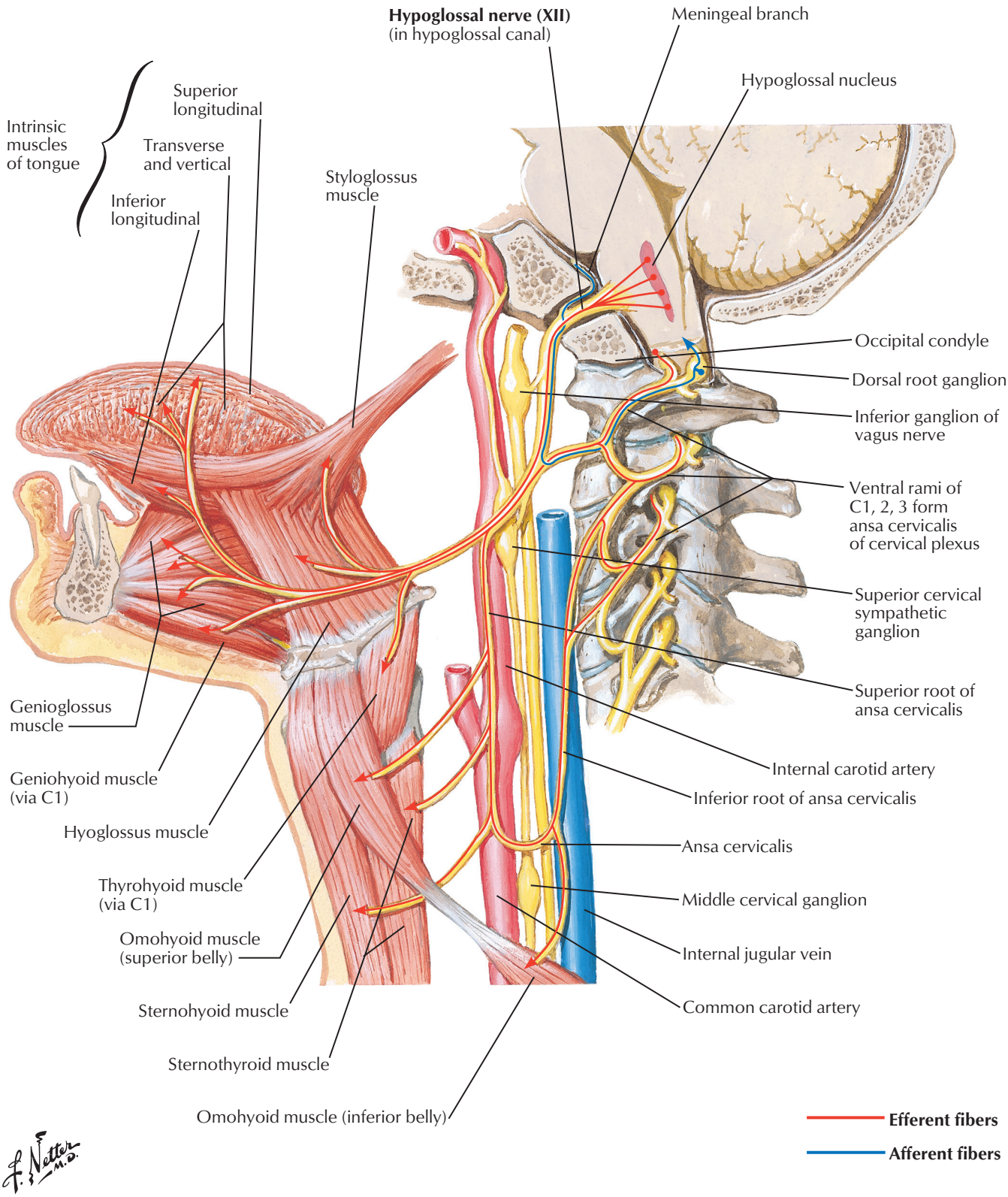
Accessory Nerve (XI): Schema

See also Plate 32



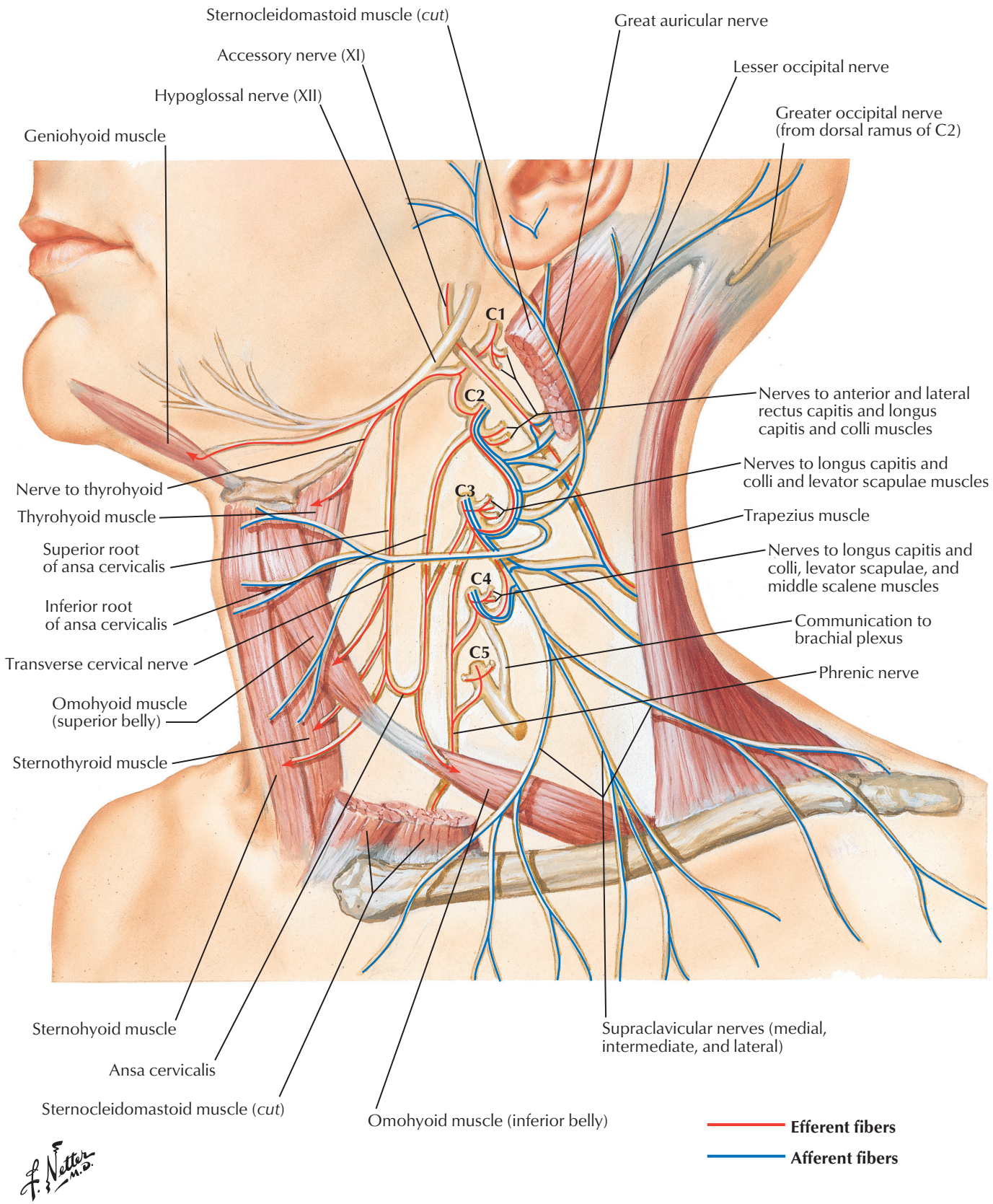
Hypoglossal Nerve (XII): Schema

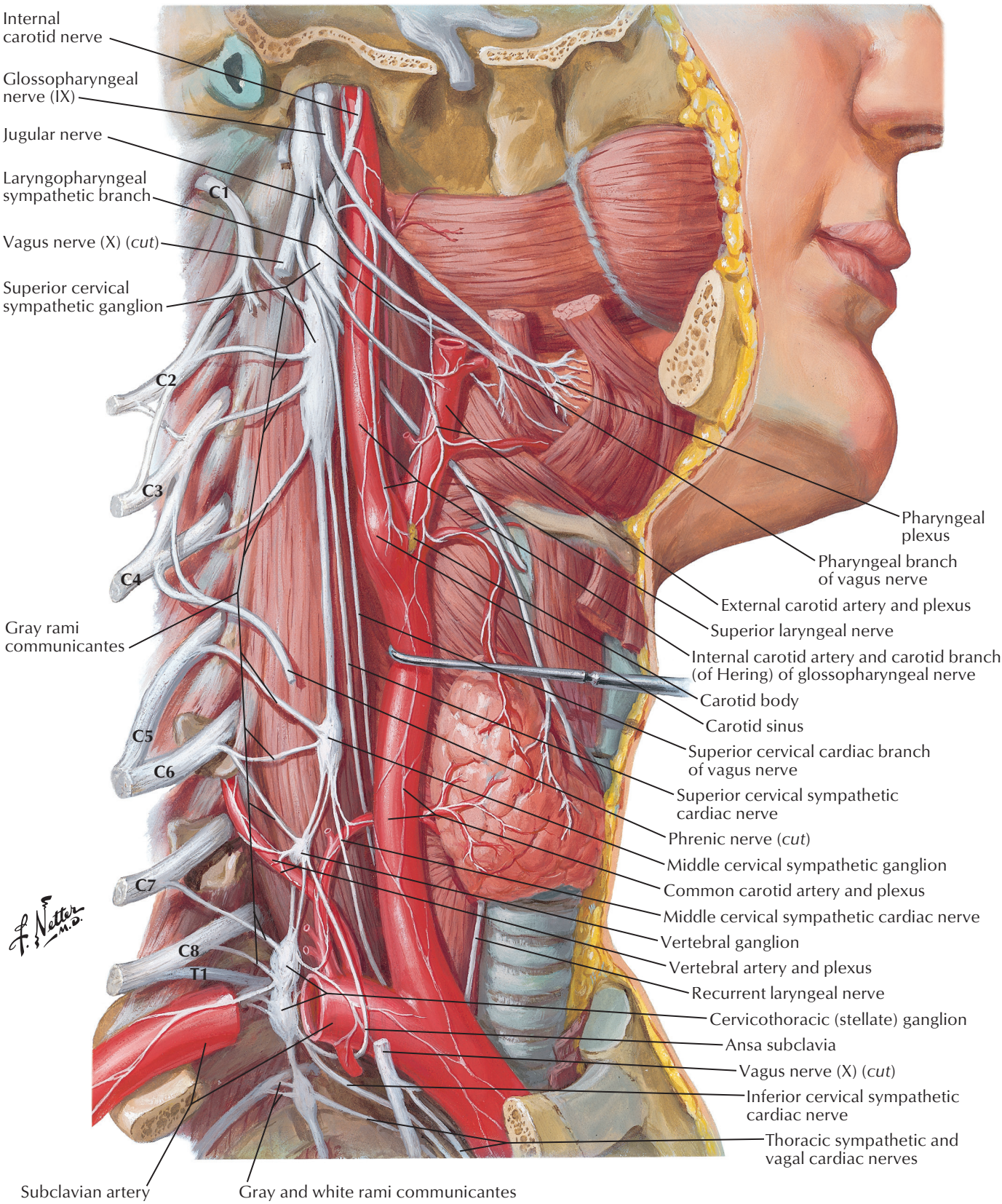
See also Plate 32



Cervical Plexus: Schema

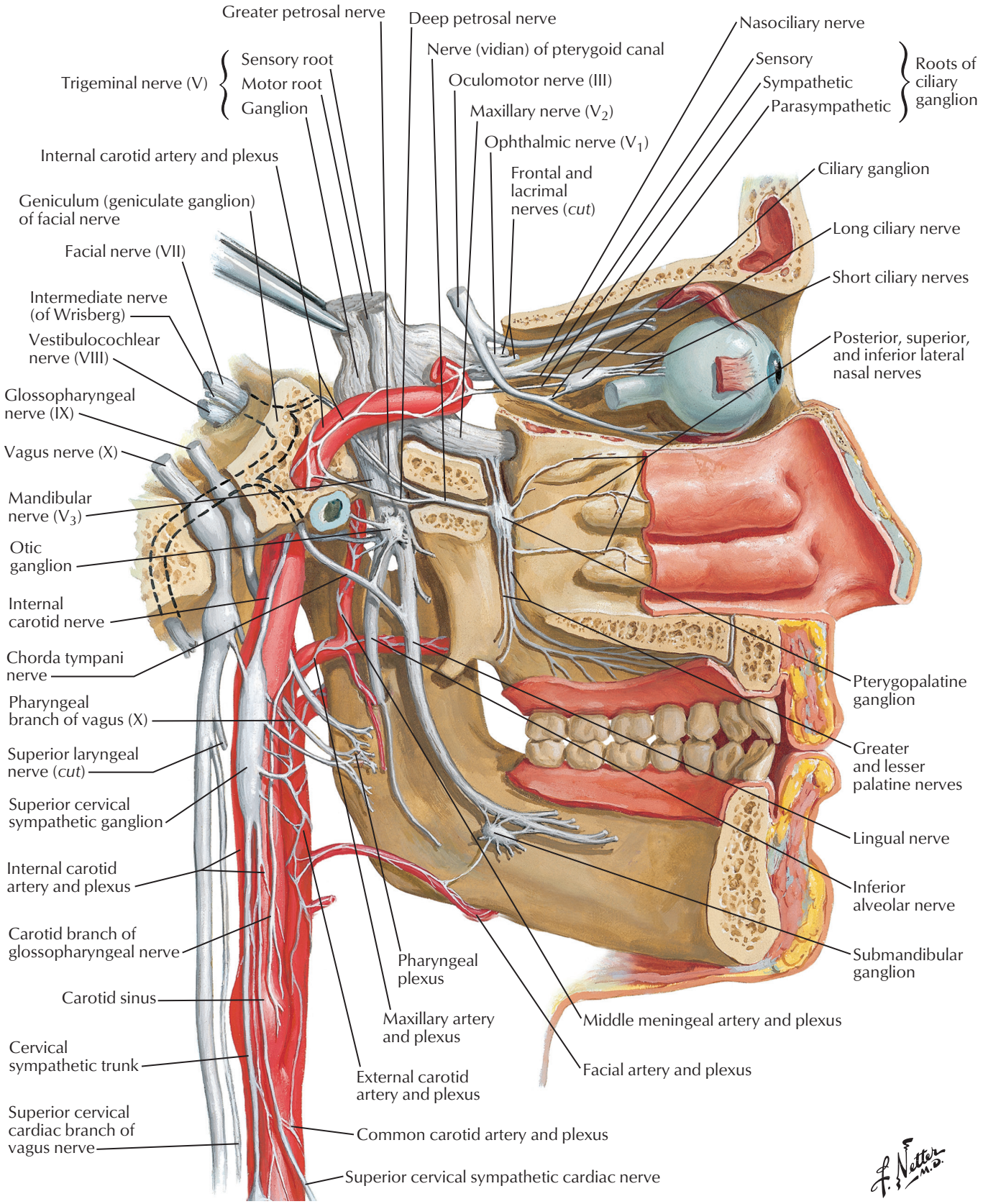
See also Plates 32, 33




Internal carotid nerve
Glossopharyngeal nerve (IX)
Jugular nerve
Laryngopharyngeal sympathetic branch
Vagus nerve (X) (cut)
Superior cervical sympathetic ganglion
C1
C2
C3
C4
C5
C6
C7
C8
T1
Gray rami communicantes
Subclavian artery
Gray and white rami communicantes
Pharyngeal plexus
Pharyngeal branch of vagus nerve
External carotid artery and plexus
Superior laryngeal nerve
Internal carotid artery and carotid branch (of Hering) of glossopharyngeal nerve
Carotid body
Carotid sinus
Superior cervical cardiac branch of vagus nerve
Superior cervical sympathetic cardiac nerve
Phrenic nerve (cut)
Middle cervical sympathetic ganglion
Common carotid artery and plexus
Middle cervical sympathetic cardiac nerve
Vertebral ganglion
Vertebral artery and plexus
Recurrent laryngeal nerve
Cervicothoracic (stellate) ganglion
Ansa subclavia
Vagus nerve (X) (cut)
Inferior cervical sympathetic cardiac nerve
Thoracic sympathetic and vagal cardiac nerves

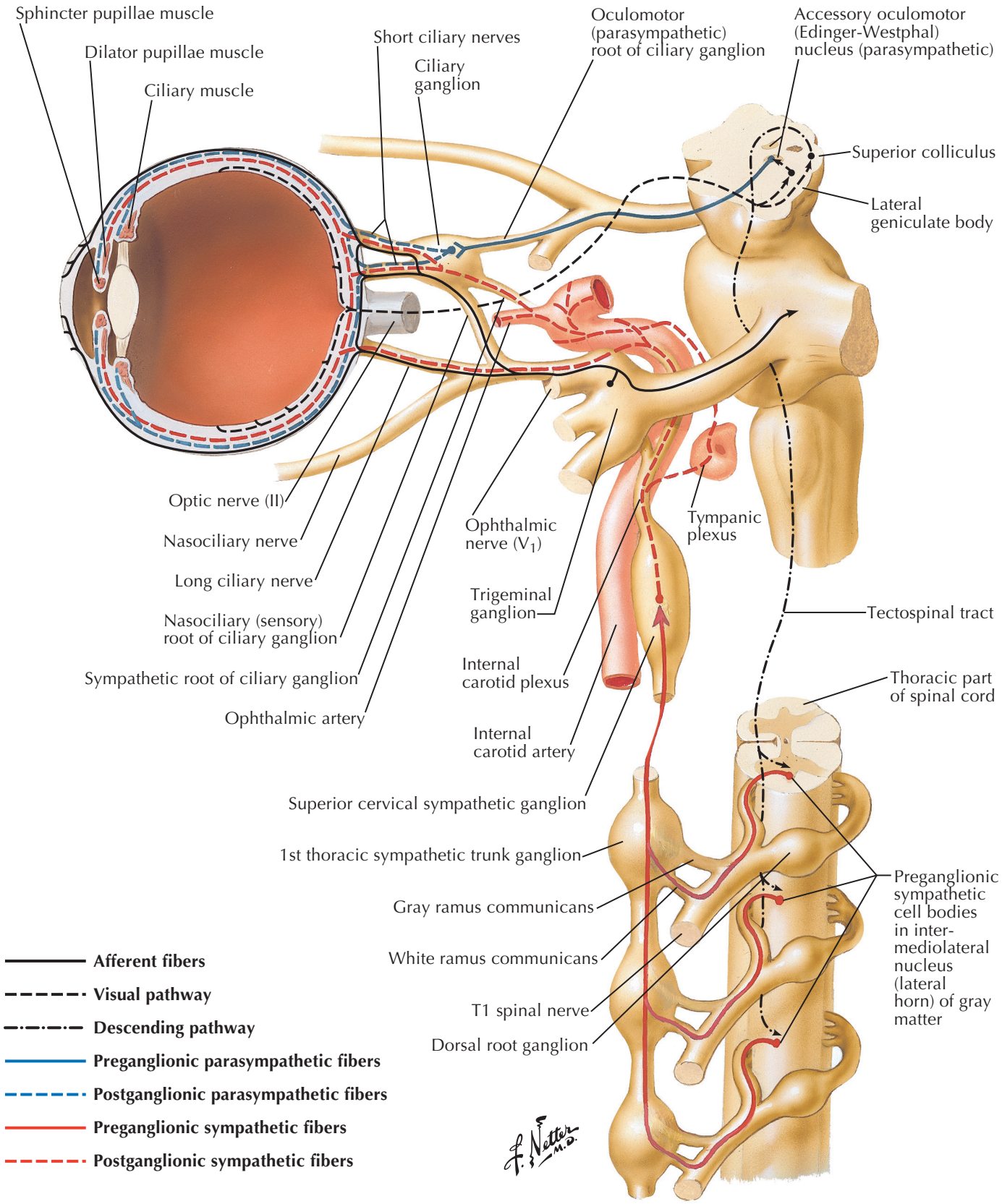
Autonomic Nerves in Head

See also Plates 53, 123, 134



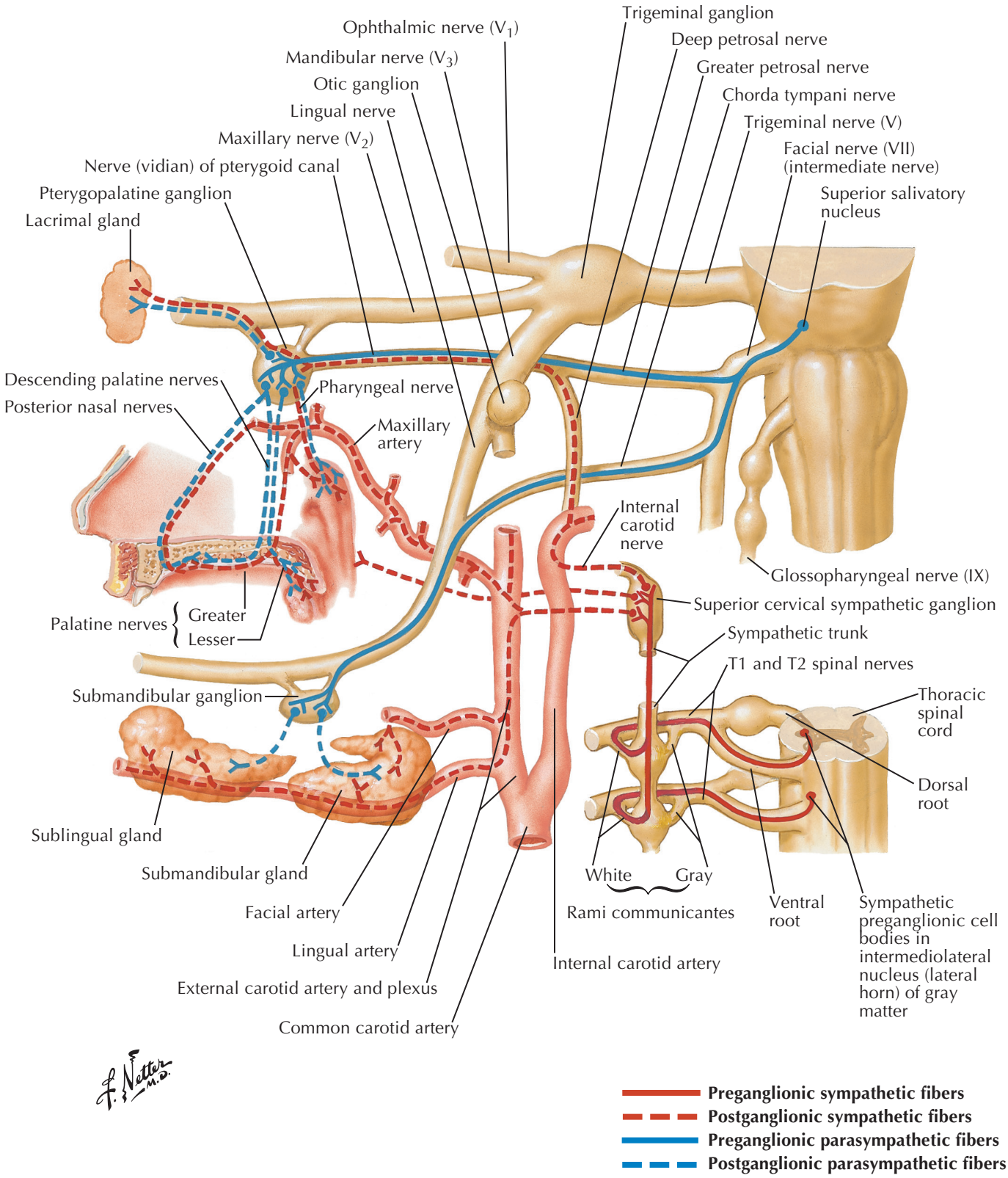
Ciliary Ganglion: Schema

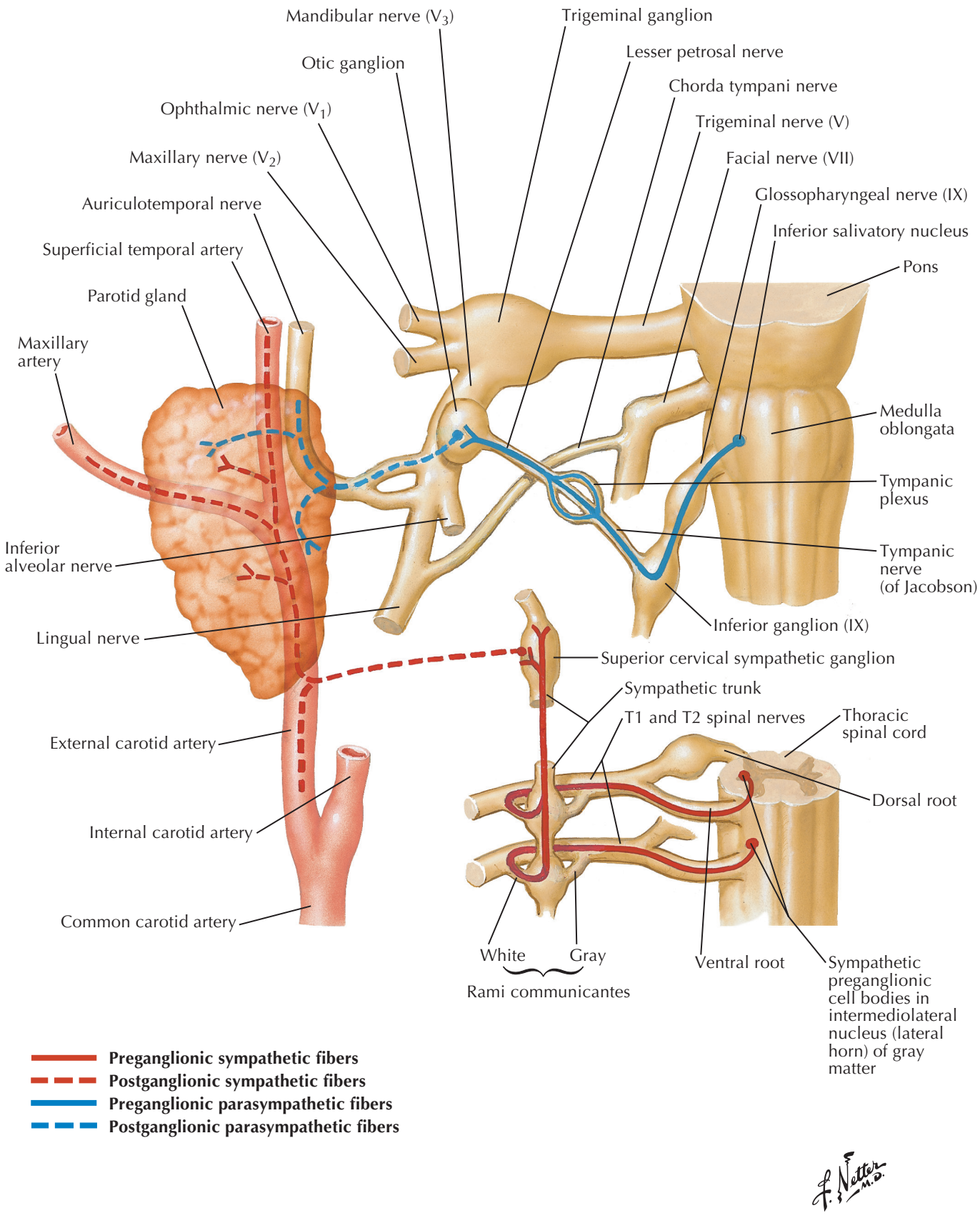
See also Plate 53



Pterygopalatine and Submandibular Ganglia: Schema

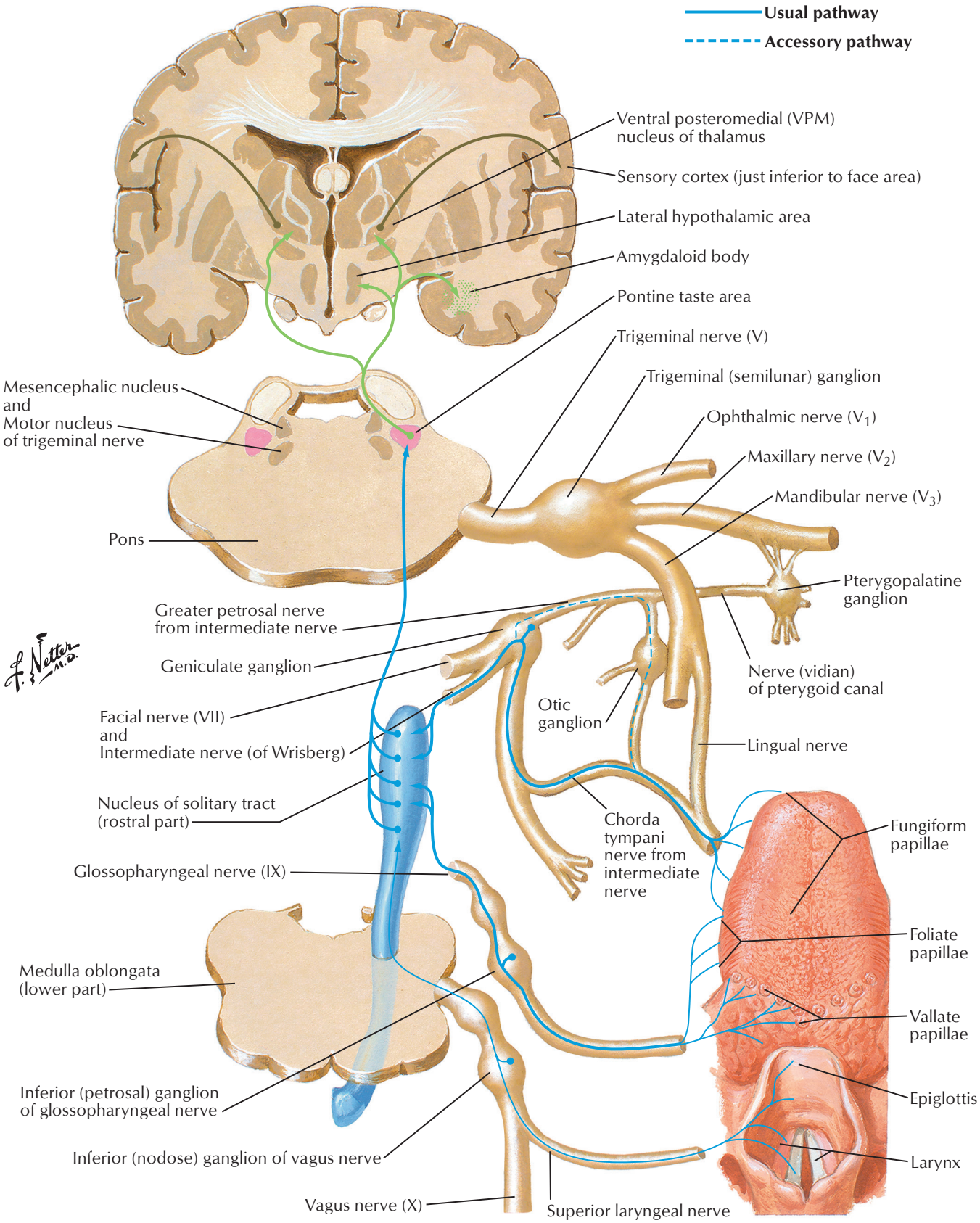
See also Plate 84

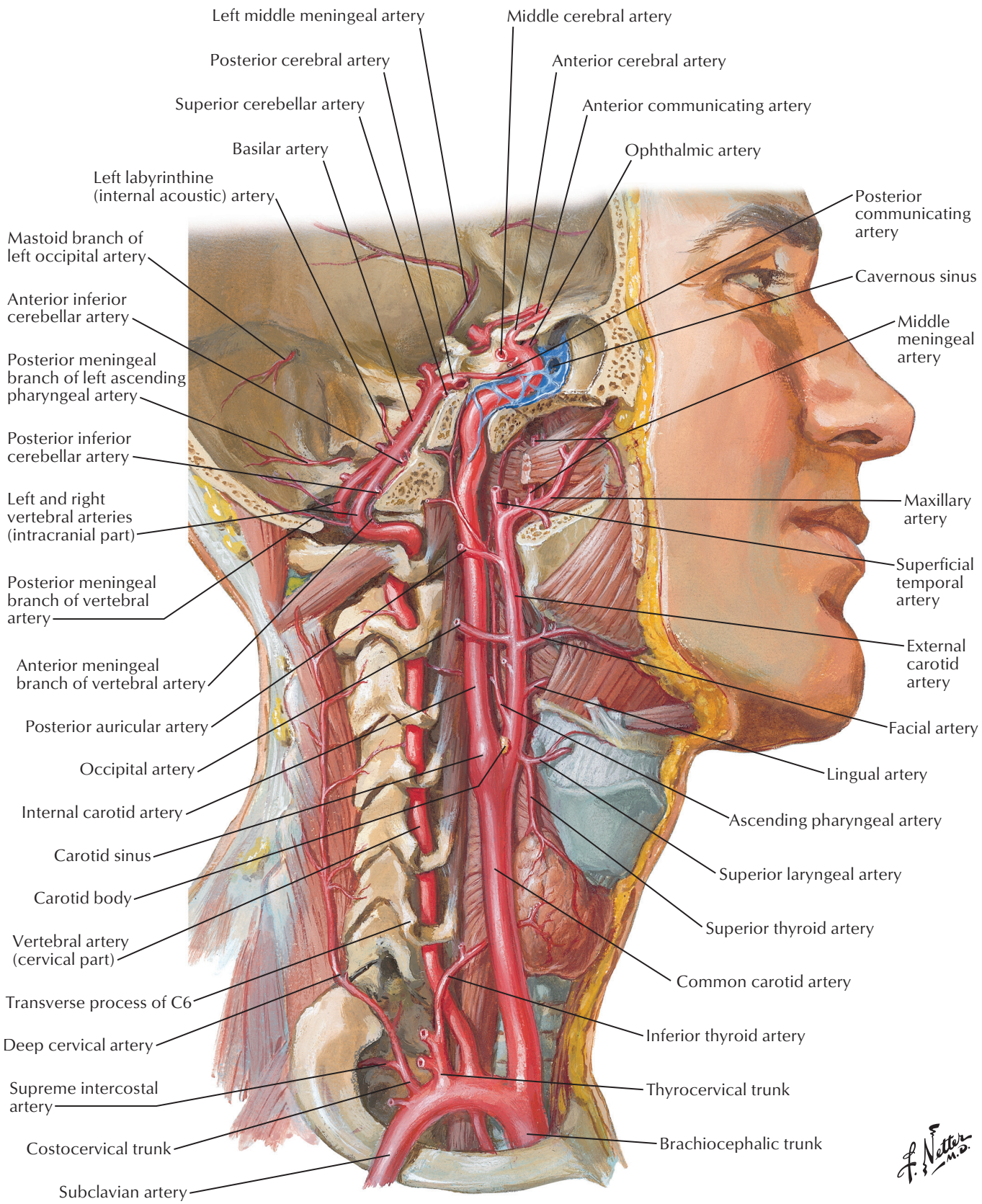



Mandibular nerve (V_3)
Trigeminal ganglion
Otic ganglion
Lesser petrosal nerve
Chorda tympani nerve
Ophthalmic nerve (V_1)
Trigeminal nerve (V)
Maxillary nerve (V_2)
Facial nerve (VII)
Auriculotemporal nerve
Glossopharyngeal nerve (IX)
Inferior salivatory nucleus
Superficial temporal artery
Pons
Parotid gland
Maxillary artery
Medulla oblongata
Tympanic plexus
Inferior alveolar nerve
Tympanic nerve (of Jacobson)
Inferior ganglion (IX)
Lingual nerve
Superior cervical sympathetic ganglion
Sympathetic trunk
T1 and T2 spinal nerves
Thoracic spinal cord
External carotid artery
Dorsal root
Internal carotid artery
Common carotid artery
White
Gray
Rami communicantes
Ventral root
Sympathetic preganglionic cell bodies in intermediolateral nucleus (lateral horn) of gray matter
Preganglionic sympathetic fibers
Postganglionic sympathetic fibers
Preganglionic parasympathetic fibers
Postganglionic parasympathetic fibers

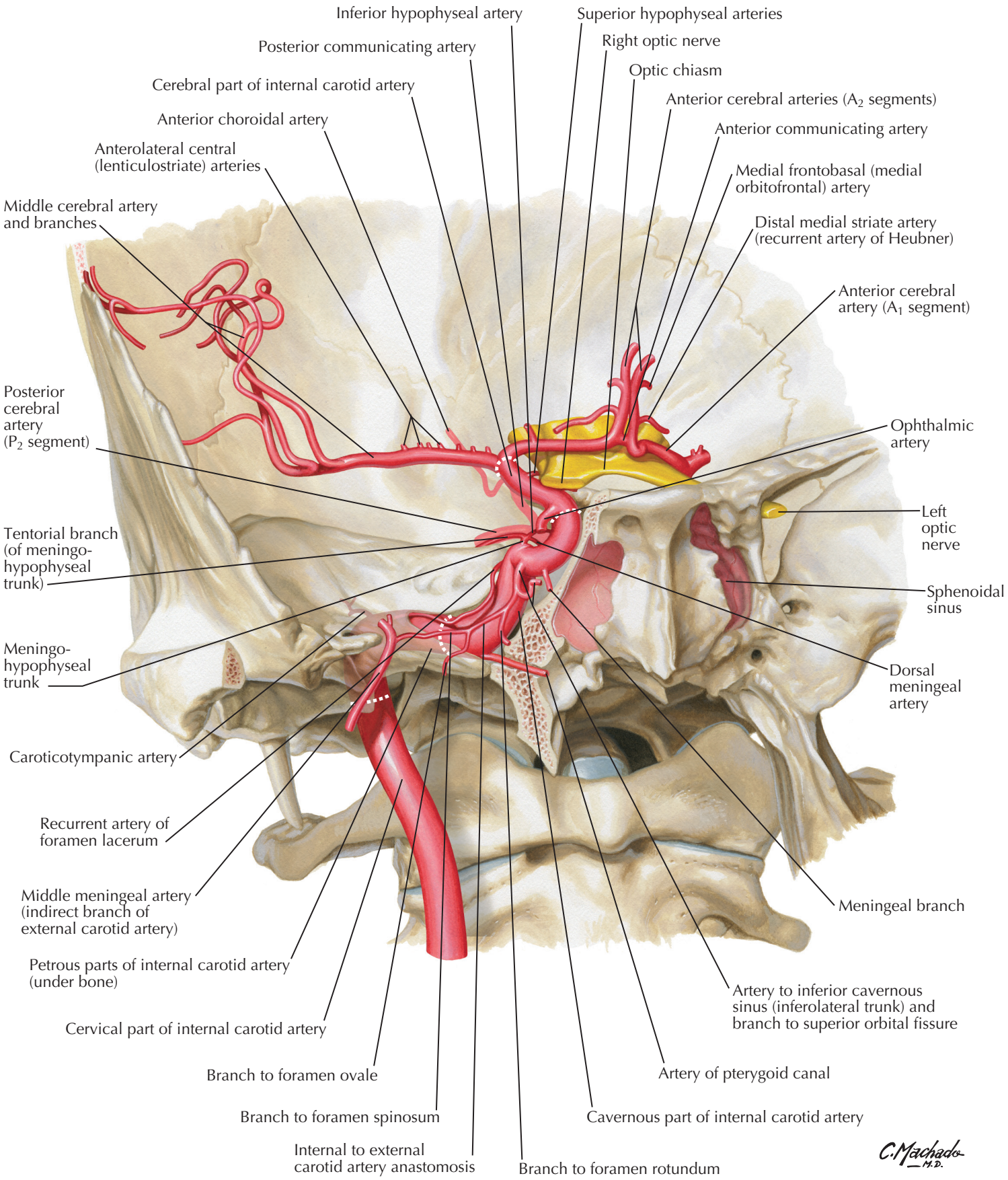
Taste Pathways: Schema

See also Plates 124, 126, 127

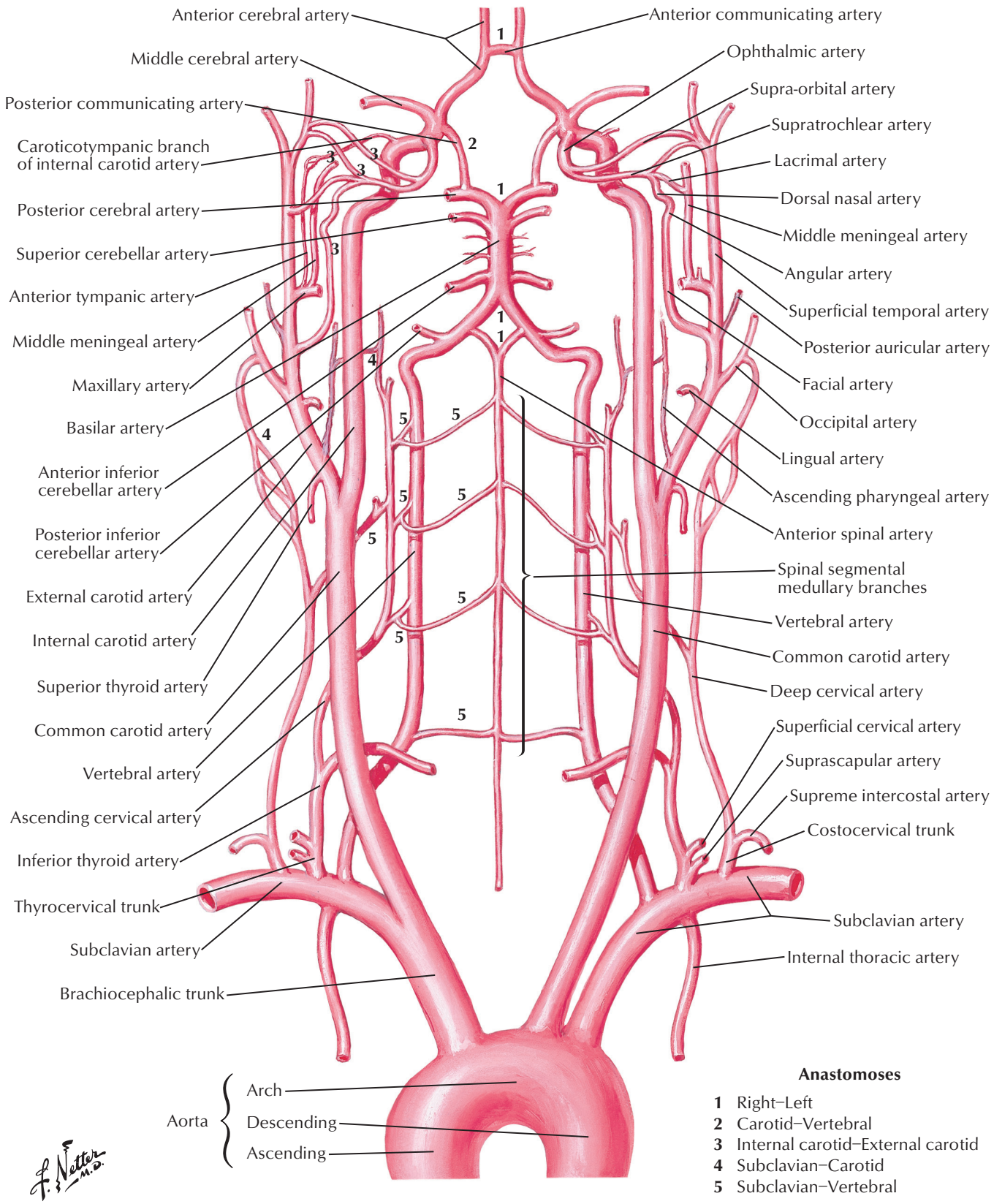


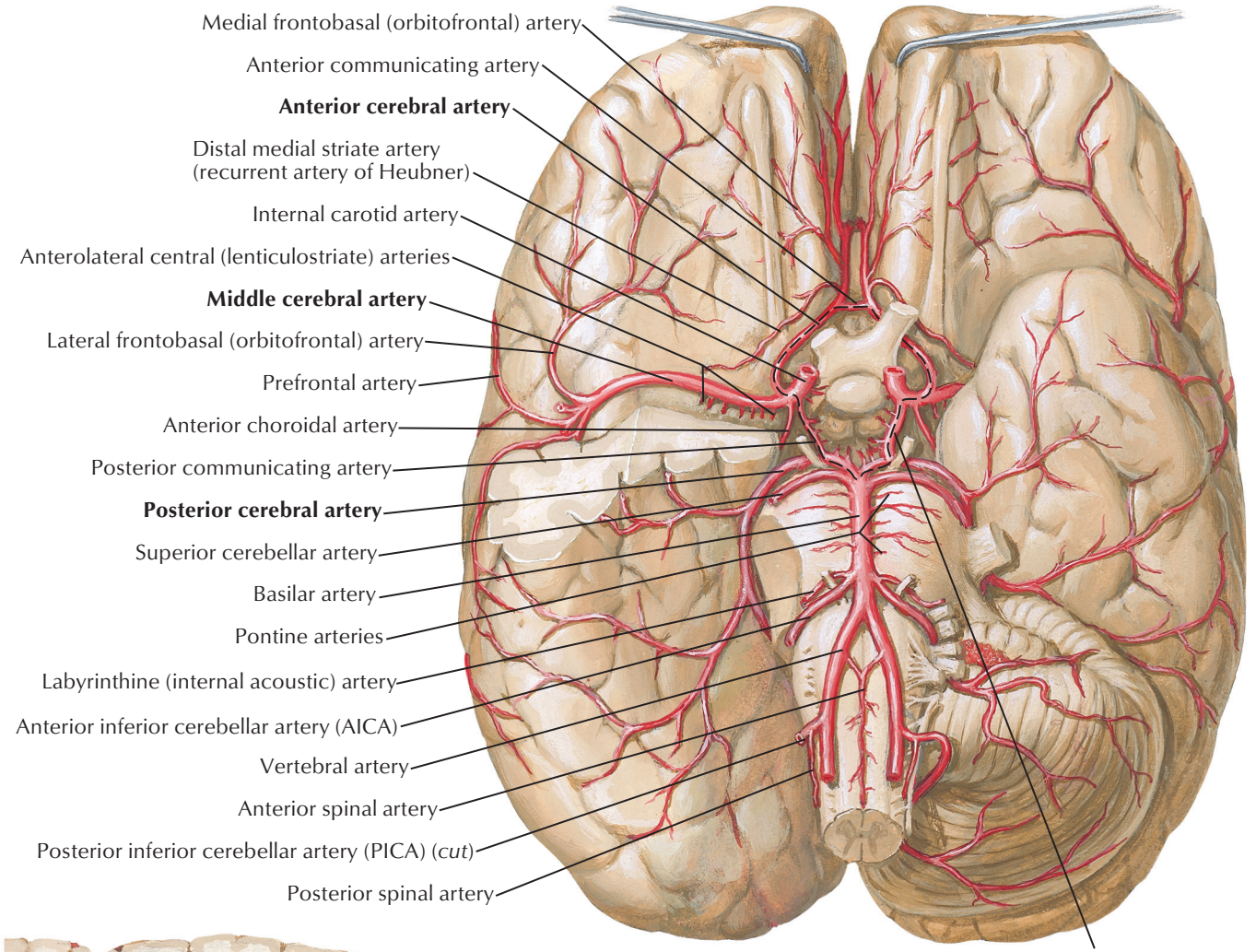

Left middle meningeal artery
Middle cerebral artery
Posterior cerebral artery
Anterior cerebral artery
Superior cerebellar artery
Anterior communicating artery
Basilar artery
Ophthalmic artery
Left labyrinthine (internal acoustic) artery
Posterior communicating artery
Mastoid branch of left occipital artery
Cavernous sinus
Anterior inferior cerebellar artery
Middle meningeal artery
Posterior meningeal branch of left ascending pharyngeal artery
Posterior inferior cerebellar artery
Left and right vertebral arteries (intracranial part)
Maxillary artery
Superficial temporal artery
Posterior meningeal branch of vertebral artery
External carotid artery
Anterior meningeal branch of vertebral artery
Facial artery
Posterior auricular artery
Lingual artery
Occipital artery
Ascending pharyngeal artery
Internal carotid artery
Superior laryngeal artery
Carotid sinus
Superior thyroid artery
Carotid body
Common carotid artery
Vertebral artery (cervical part)
Inferior thyroid artery
Transverse process of C6
Thyrocervical trunk
Deep cervical artery
Brachiocephalic trunk
Supreme intercostal artery
Costocervical trunk
Subclavian artery
F. Netter M.D.

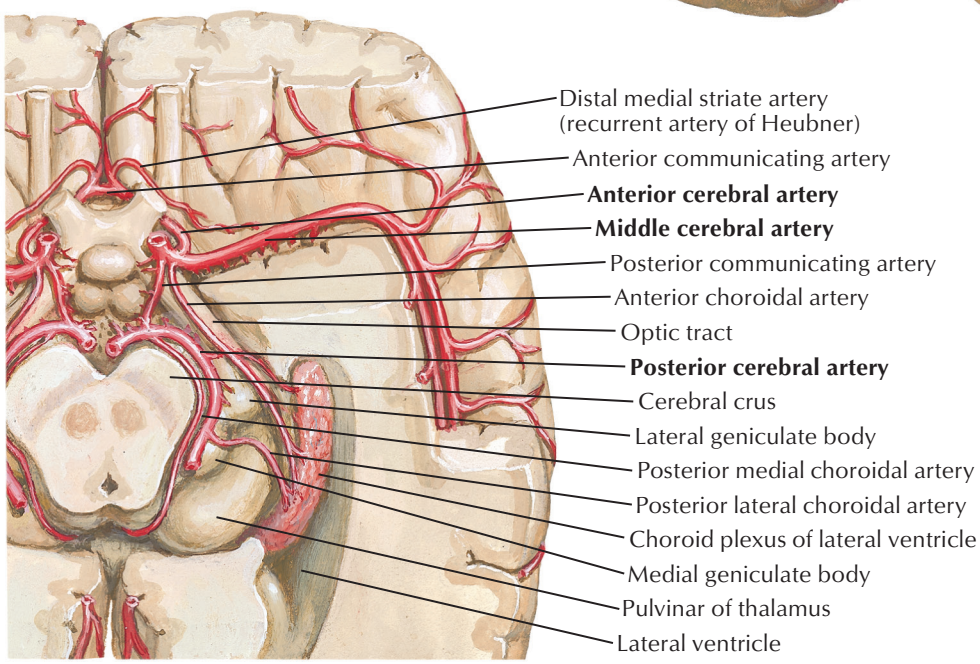
Internal Carotid Artery in Petrous Part of Temporal Bone



C. Machado M.D.


Anterior cerebral artery
Middle cerebral artery
Posterior communicating artery
Caroticotympanic branch of internal carotid artery
Posterior cerebral artery
Superior cerebellar artery
Anterior tympanic artery
Middle meningeal artery
Maxillary artery
Basilar artery
Anterior inferior cerebellar artery
Posterior inferior cerebellar artery
External carotid artery
Internal carotid artery
Superior thyroid artery
Common carotid artery
Vertebral artery
Ascending cervical artery
Inferior thyroid artery
Thyrocervical trunk
Subclavian artery
Brachiocephalic trunk
Anterior communicating artery
Ophthalmic artery
Supra-orbital artery
Supratrochlear artery
Lacrimal artery
Dorsal nasal artery
Middle meningeal artery
Angular artery
Superficial temporal artery
Posterior auricular artery
Facial artery
Occipital artery
Lingual artery
Ascending pharyngeal artery
Anterior spinal artery
Spinal segmental medullary branches
Vertebral artery
Common carotid artery
Deep cervical artery
Superficial cervical artery
Suprascapular artery
Supreme intercostal artery
Costocervical trunk
Subclavian artery
Internal thoracic artery
Aorta
Arch
Descending
Ascending
1
2
3
4
5
Anastomoses
1 Right–Left
2 Carotid–Vertebral
3 Internal carotid–External carotid
4 Subclavian–Carotid
5 Subclavian–Vertebral

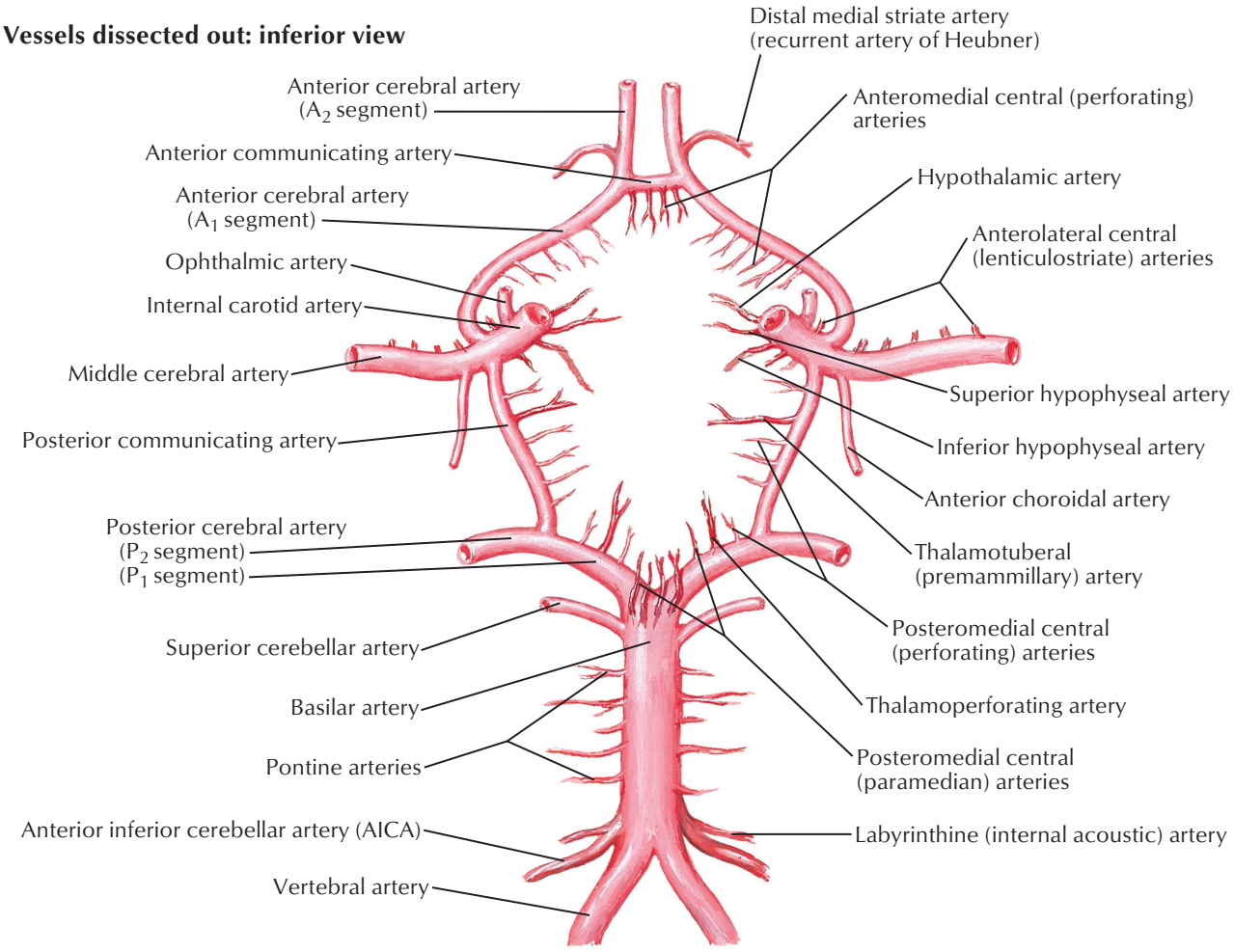

Medial frontobasal (orbitofrontal) artery
Anterior communicating artery
Anterior cerebral artery
Distal medial striate artery (recurrent artery of Heubner)
Internal carotid artery
Anterolateral central (lenticulostriate) arteries
Middle cerebral artery
Lateral frontobasal (orbitofrontal) artery
Prefrontal artery
Anterior choroidal artery
Posterior communicating artery
Posterior cerebral artery
Superior cerebellar artery
Basilar artery
Pontine arteries
Labyrinthine (internal acoustic) artery
Anterior inferior cerebellar artery (AICA)
Vertebral artery
Anterior spinal artery
Posterior inferior cerebellar artery (PICA) (cut)
Posterior spinal artery
Cerebral arterial circle (of Willis) (broken line)


Distal medial striate artery (recurrent artery of Heubner)
Anterior communicating artery
Anterior cerebral artery
Middle cerebral artery
Posterior communicating artery
Anterior choroidal artery
Optic tract
Posterior cerebral artery
Cerebral crus
Lateral geniculate body
Posterior medial choroidal artery
Posterior lateral choroidal artery
Choroid plexus of lateral ventricle
Medial geniculate body
Pulvinar of thalamus
Lateral ventricle

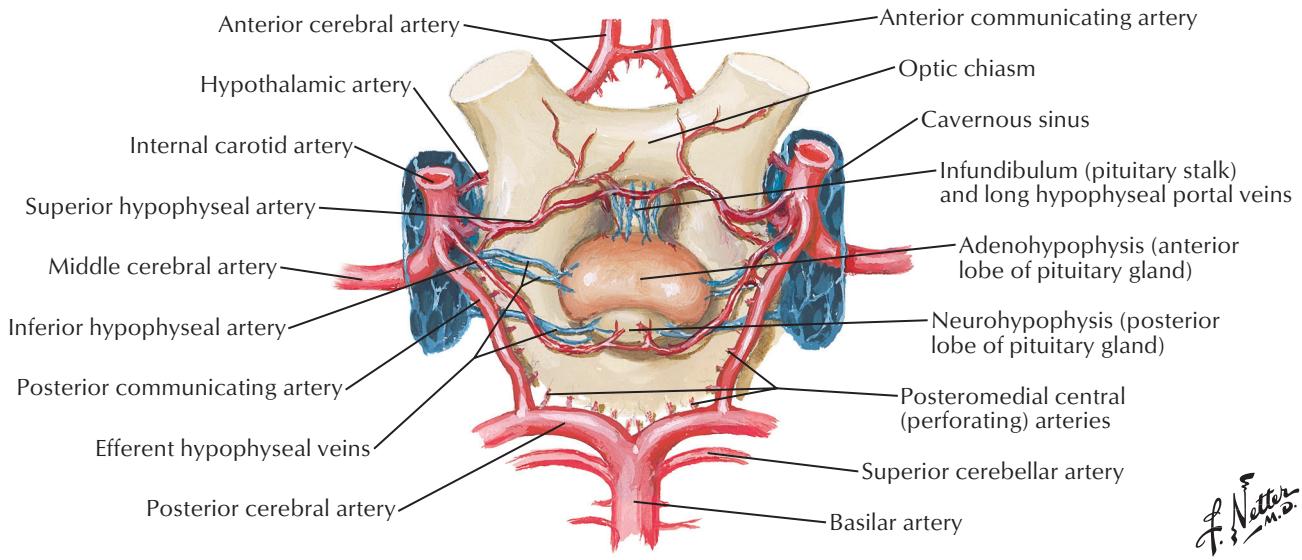
Cerebral Arterial Circle (of Willis)

For hypophyseal arteries see **Plate 149**

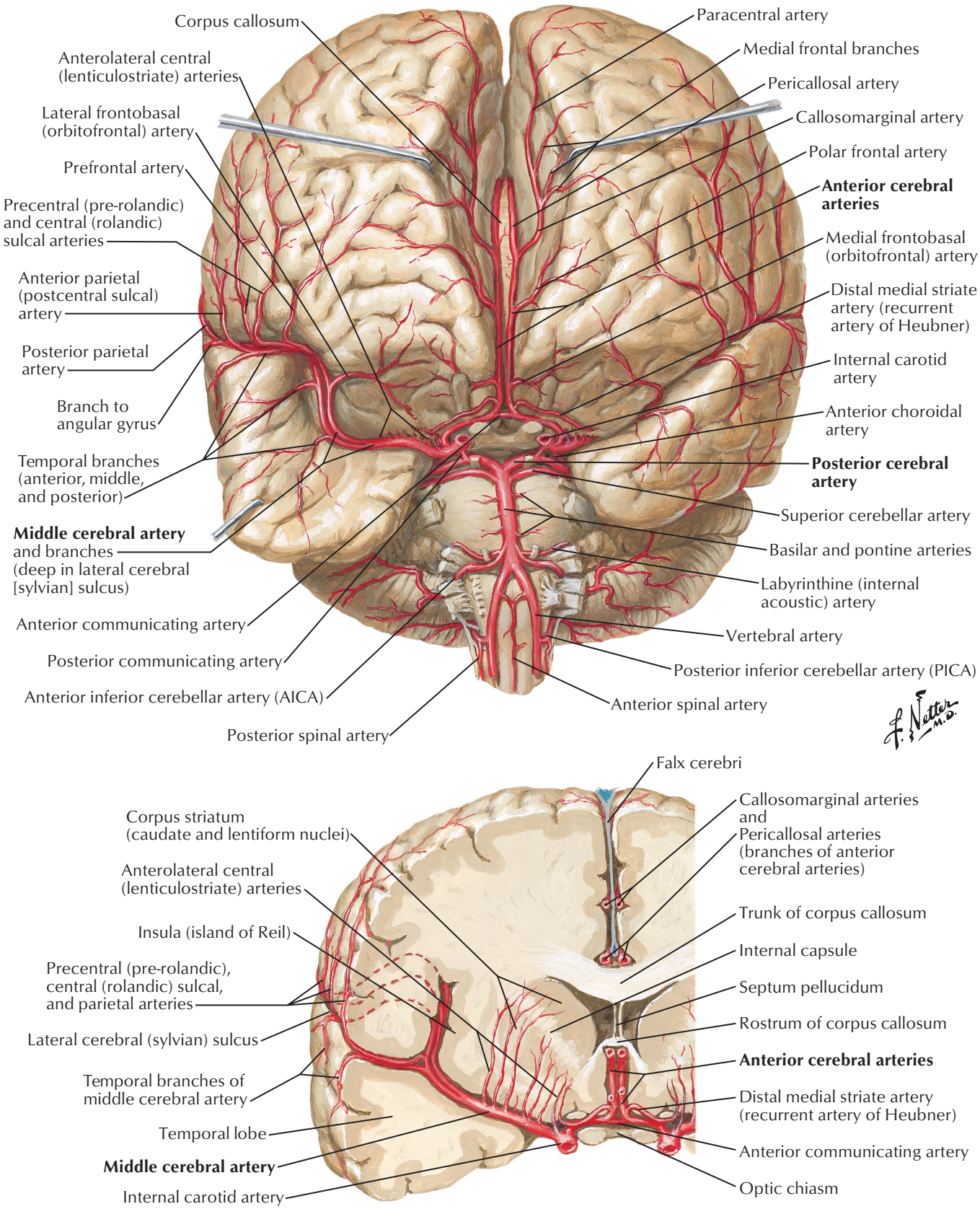
Vessels dissected out: inferior view

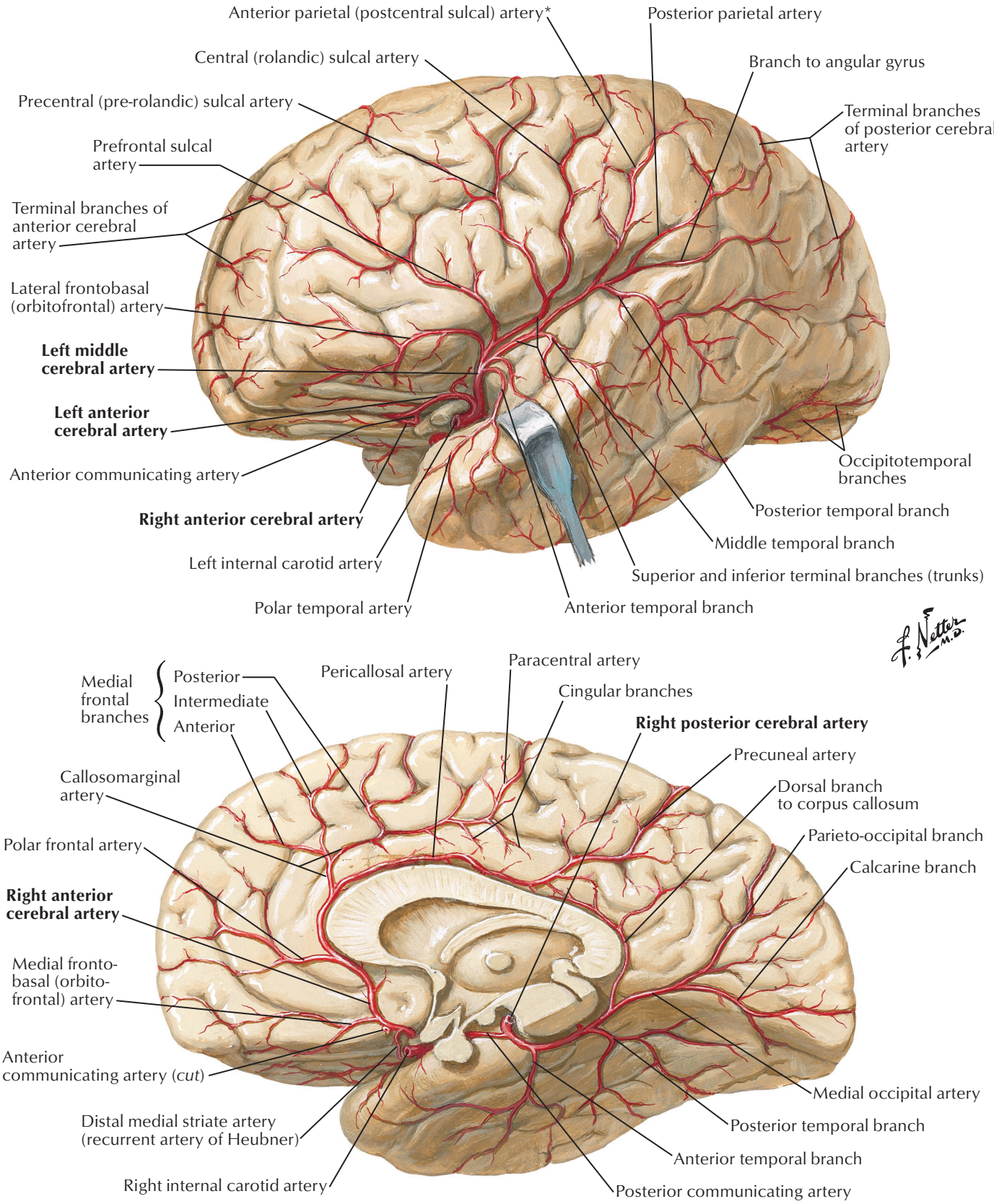


Vessels in situ: inferior view

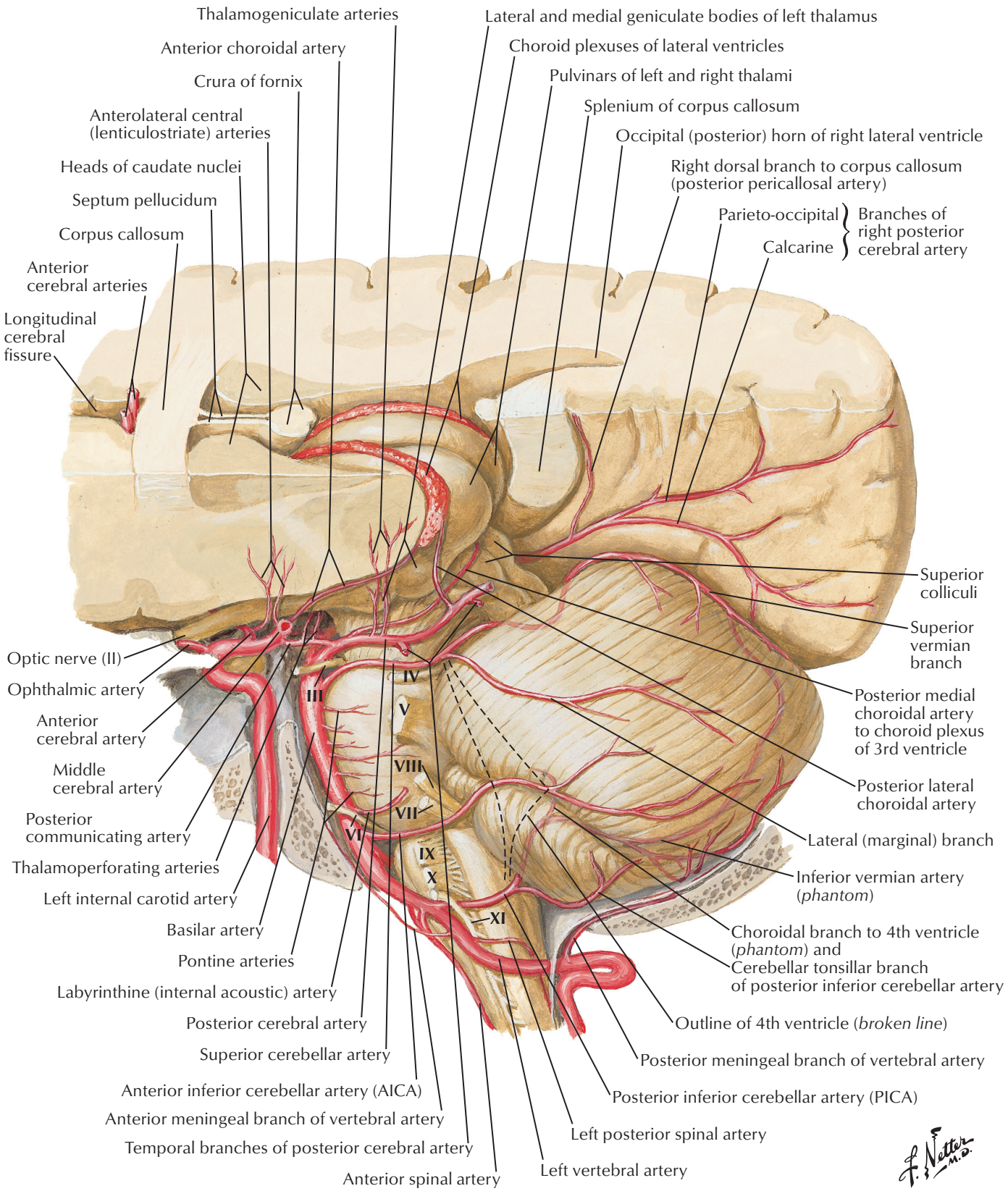


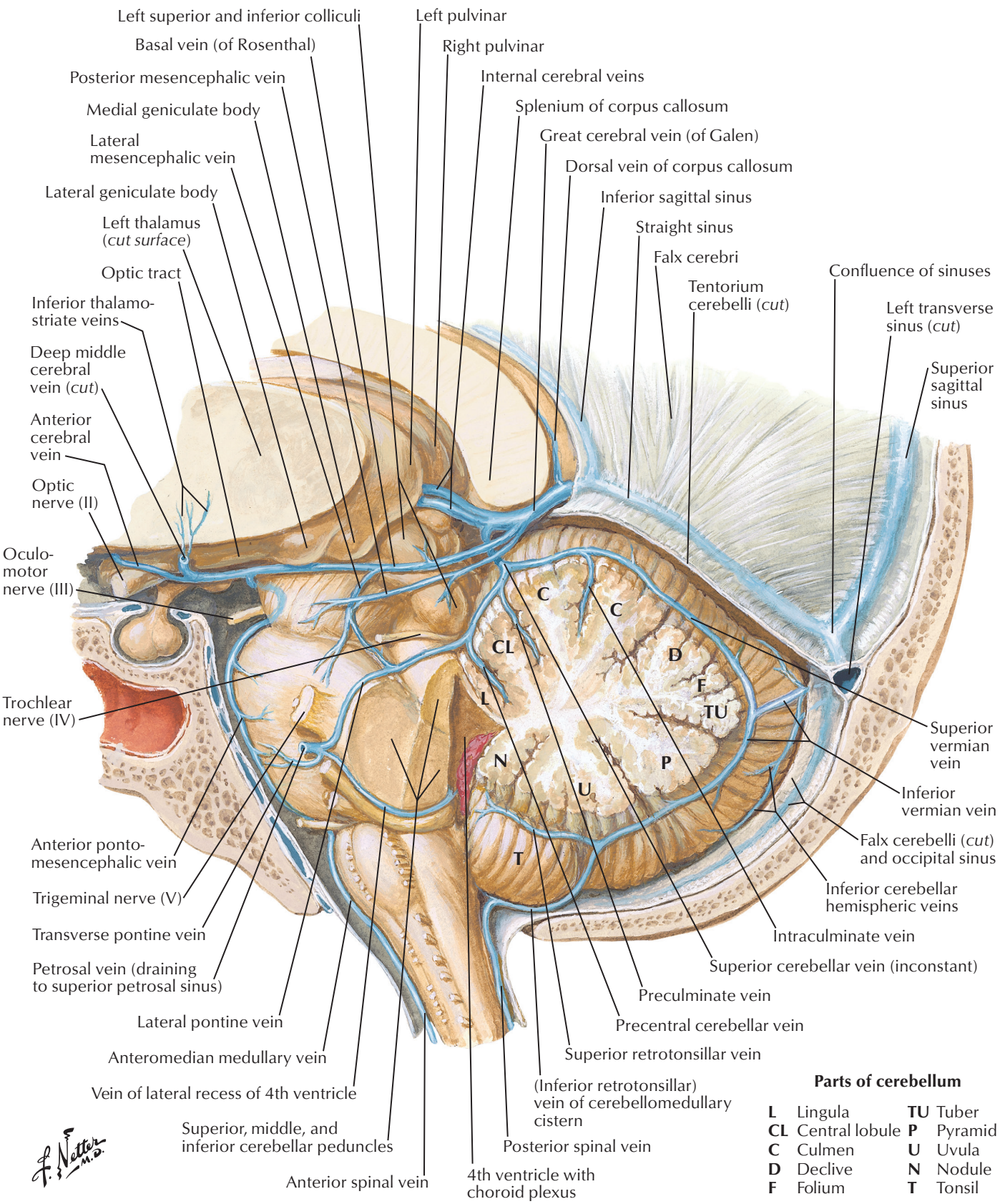
Arteries of Brain: Frontal View and Section





*Note: Anterior parietal (postcentral sulcal) artery also occurs as separate anterior parietal and postcentral sulcal arteries.


Thalamogeniculate arteries
Anterior choroidal artery
Crura of fornix
Anterolateral central (lenticulostriate) arteries
Heads of caudate nuclei
Septum pellucidum
Corpus callosum
Anterior cerebral arteries
Longitudinal cerebral fissure
Lateral and medial geniculate bodies of left thalamus
Choroid plexuses of lateral ventricles
Pulvinars of left and right thalami
Splenium of corpus callosum
Occipital (posterior) horn of right lateral ventricle
Right dorsal branch to corpus callosum (posterior pericallosal artery)
Parieto-occipital
Calcarine
Branches of right posterior cerebral artery
Superior colliculi
Superior vermian branch
Posterior medial choroidal artery to choroid plexus of 3rd ventricle
Posterior lateral choroidal artery
Lateral (marginal) branch
Inferior vermian artery (phantom)
Choroidal branch to 4th ventricle (phantom) and
Cerebellar tonsillar branch of posterior inferior cerebellar artery
Outline of 4th ventricle (broken line)
Posterior meningeal branch of vertebral artery
Posterior inferior cerebellar artery (PICA)
Left posterior spinal artery
Left vertebral artery
Optic nerve (II)
Ophthalmic artery
Anterior cerebral artery
Middle cerebral artery
Posterior communicating artery
Thalamoperforating arteries
Left internal carotid artery
Basilar artery
Pontine arteries
Labyrinthine (internal acoustic) artery
Posterior cerebral artery
Superior cerebellar artery
Anterior inferior cerebellar artery (AICA)
Anterior meningeal branch of vertebral artery
Temporal branches of posterior cerebral artery
Anterior spinal artery
III
IV
V
VI
VII
VIII
IX
X
XI

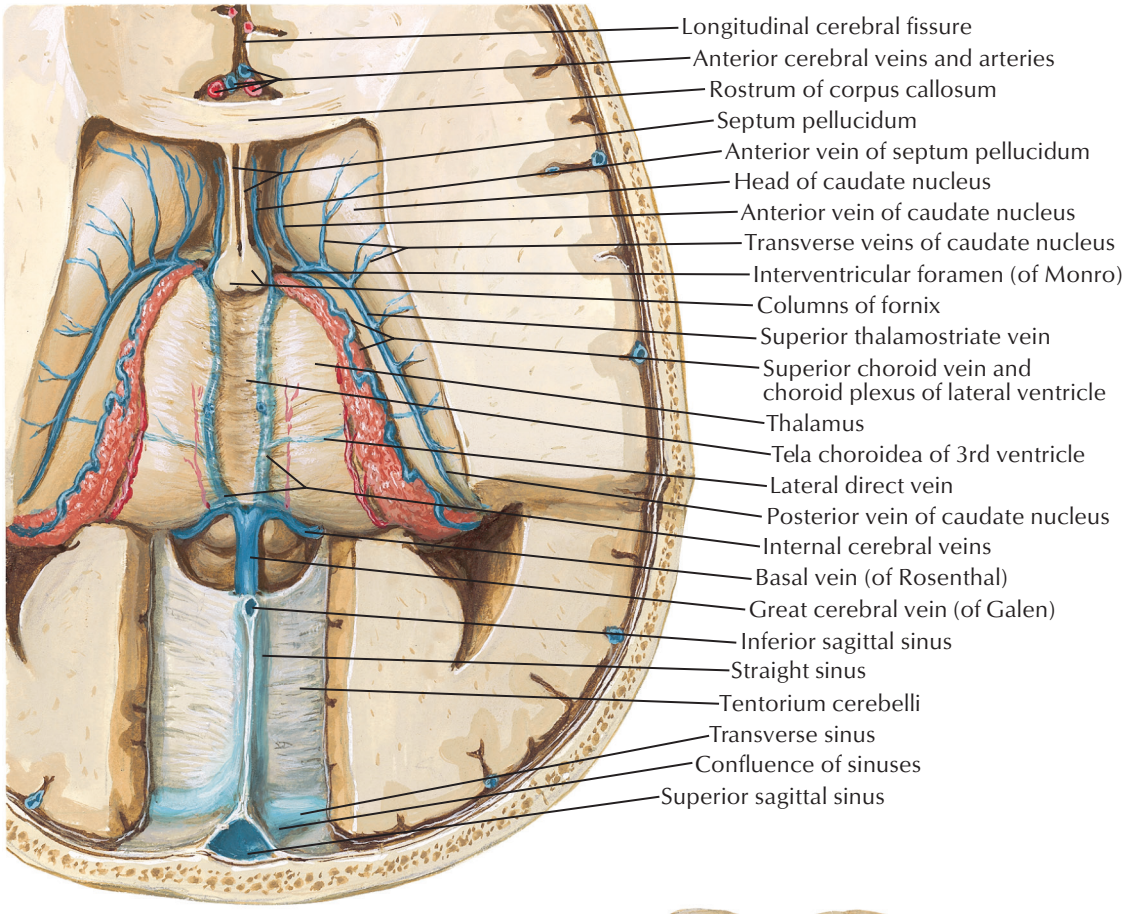


Parts of cerebellum

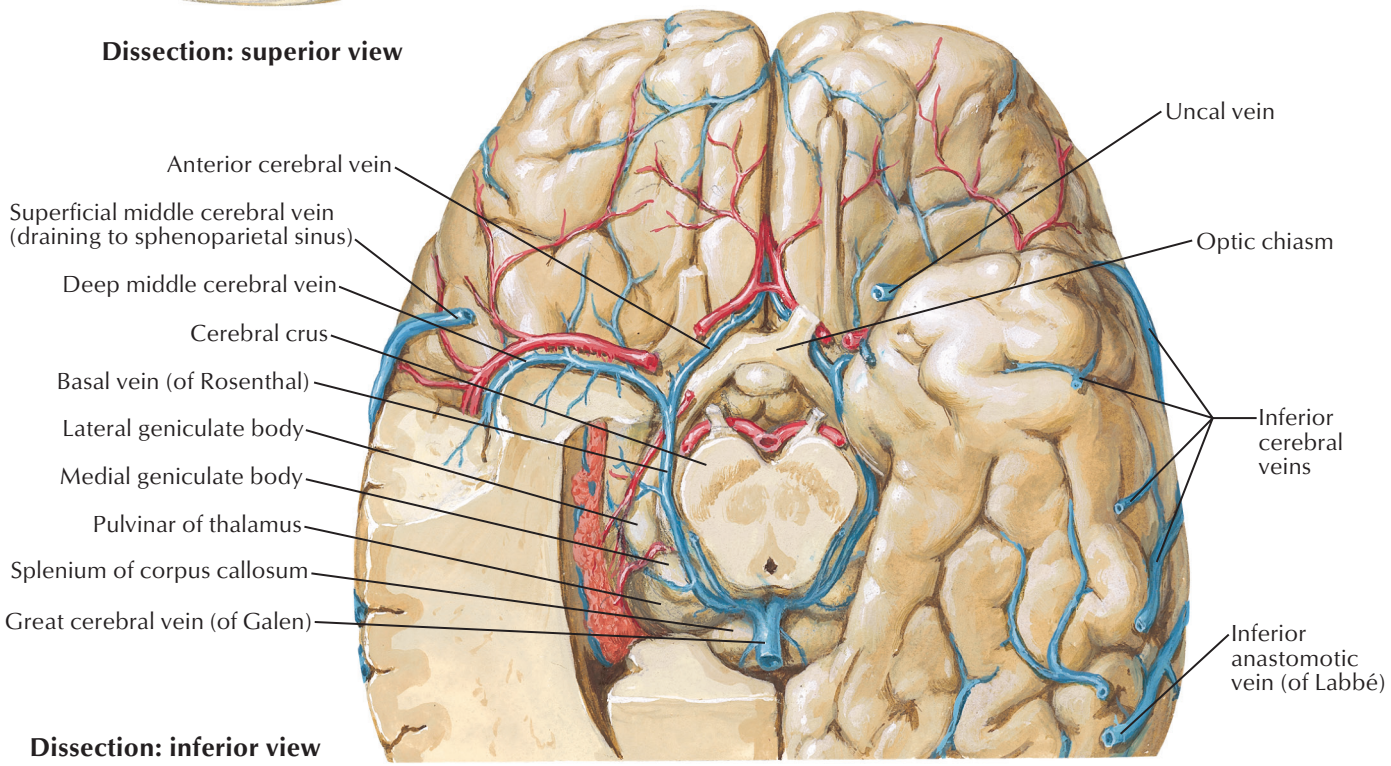
L	Lingula	**TU**	Tuber
CL	Central lobule	**P**	Pyramid
C	Culmen	**U**	Uvula
D	Declive	**N**	Nodule
F	Folium	**T**	Tonsil

Deep Veins of Brain

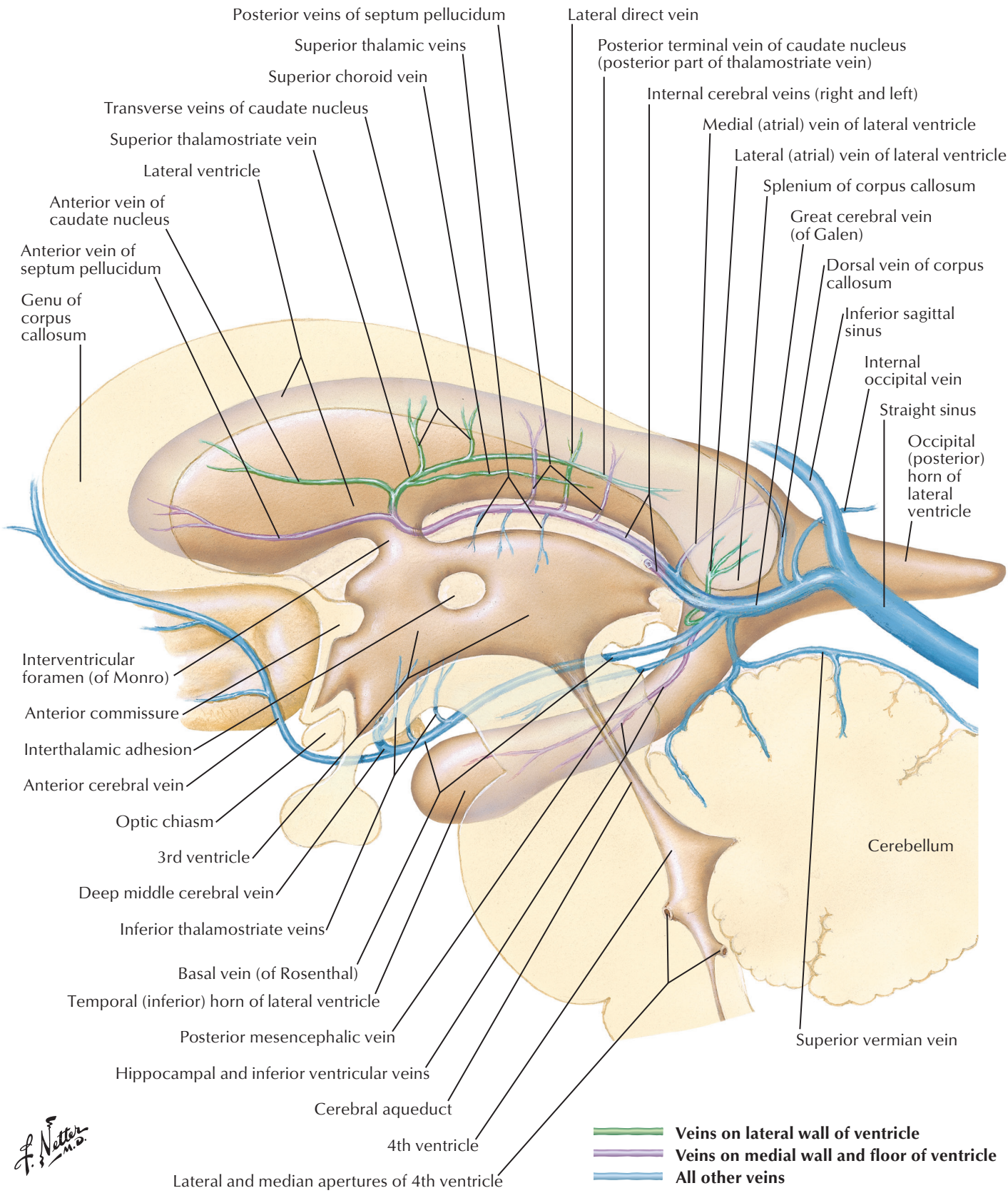
For superficial veins of brain see Plate 103



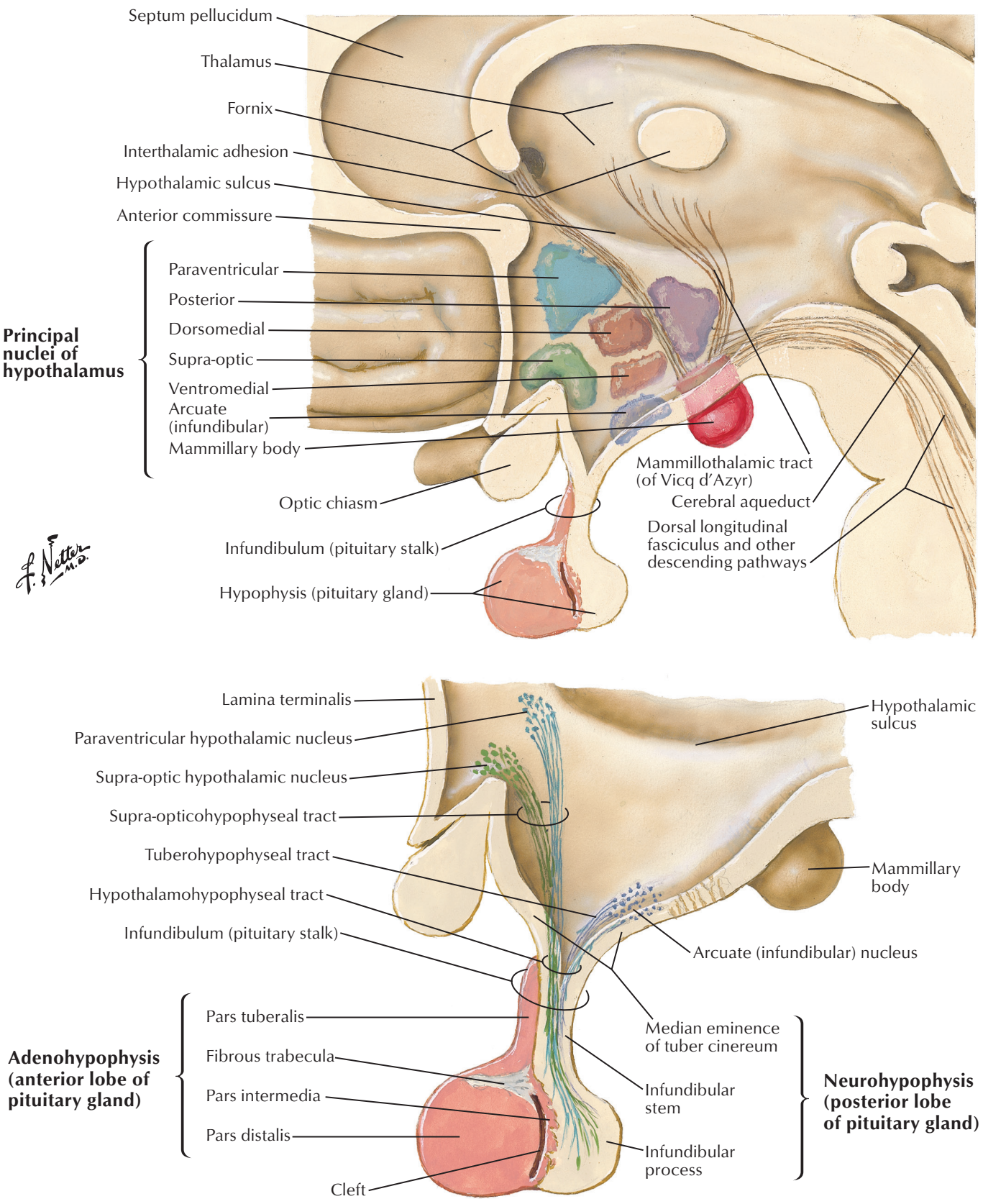
Dissection: superior view

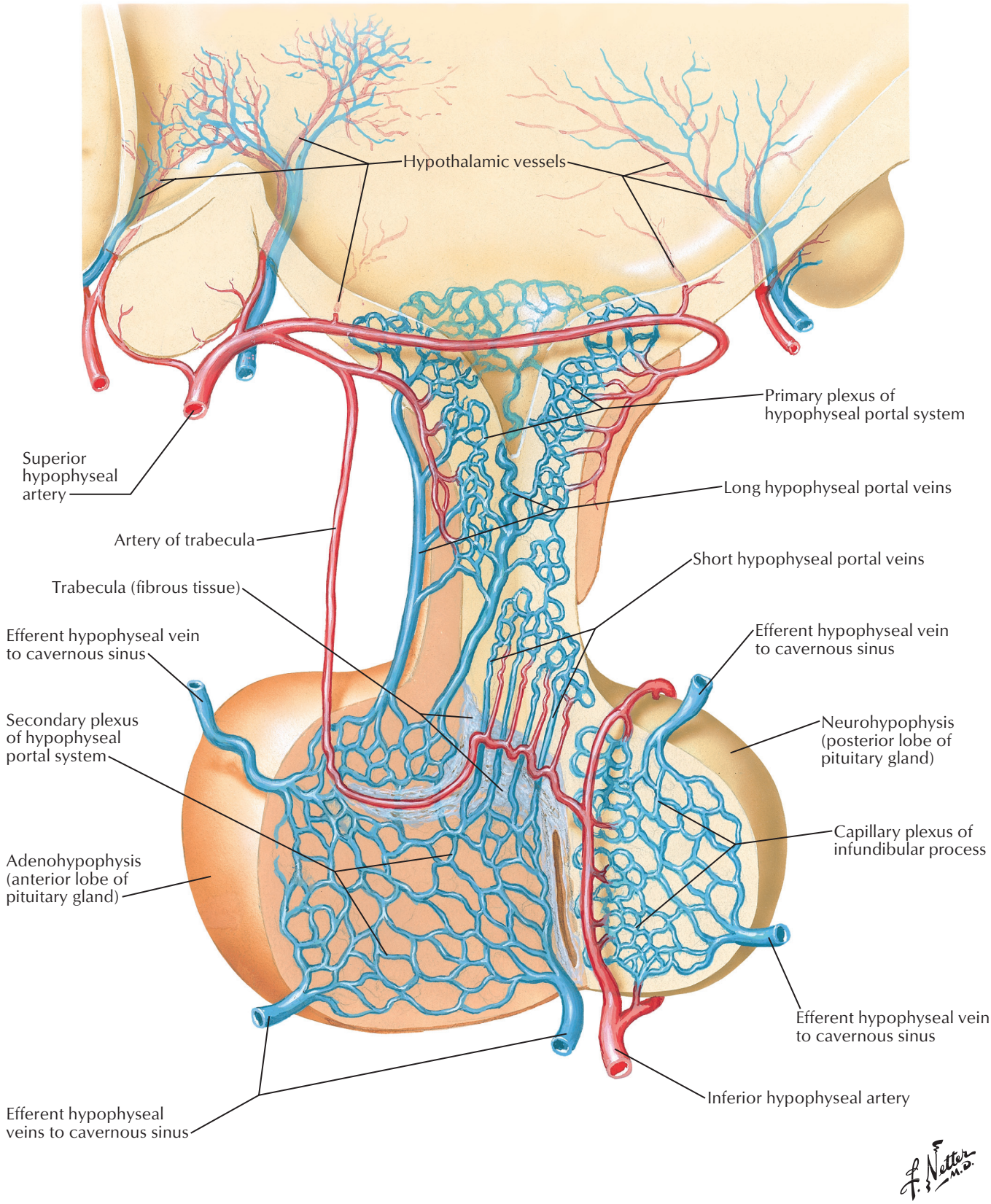


Dissection: inferior view


Posterior veins of septum pellucidum
Superior thalamic veins
Superior choroid vein
Transverse veins of caudate nucleus
Superior thalamostriate vein
Lateral ventricle
Anterior vein of caudate nucleus
Anterior vein of septum pellucidum
Genu of corpus callosum
Lateral direct vein
Posterior terminal vein of caudate nucleus (posterior part of thalamostriate vein)
Internal cerebral veins (right and left)
Medial (atrial) vein of lateral ventricle
Lateral (atrial) vein of lateral ventricle
Splenium of corpus callosum
Great cerebral vein (of Galen)
Dorsal vein of corpus callosum
Inferior sagittal sinus
Internal occipital vein
Straight sinus
Occipital (posterior) horn of lateral ventricle
Interventricular foramen (of Monro)
Anterior commissure
Interthalamic adhesion
Anterior cerebral vein
Optic chiasm
3rd ventricle
Deep middle cerebral vein
Inferior thalamostriate veins
Basal vein (of Rosenthal)
Temporal (inferior) horn of lateral ventricle
Posterior mesencephalic vein
Hippocampal and inferior ventricular veins
Cerebral aqueduct
4th ventricle
Lateral and median apertures of 4th ventricle
Cerebellum
Superior vermian vein
Veins on lateral wall of ventricle
Veins on medial wall and floor of ventricle
All other veins

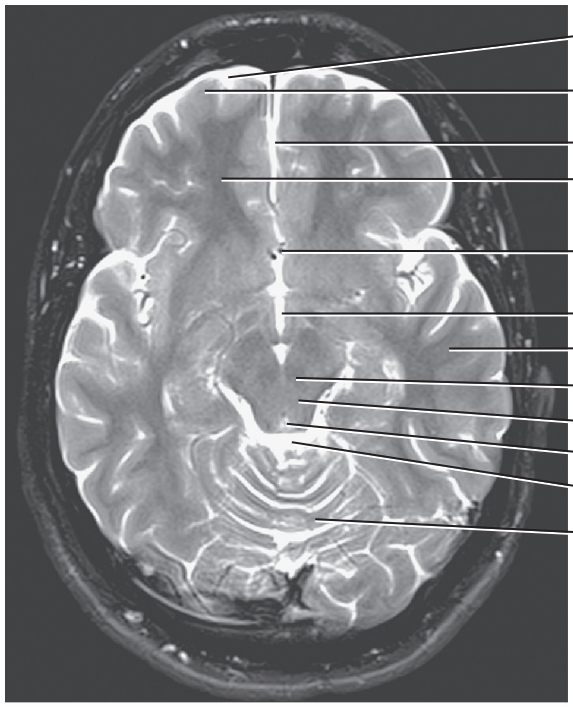
See also Plates 107, 108

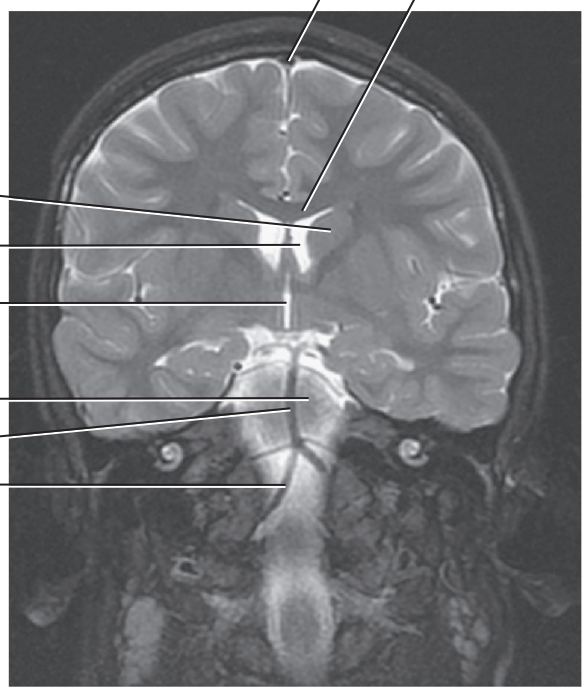


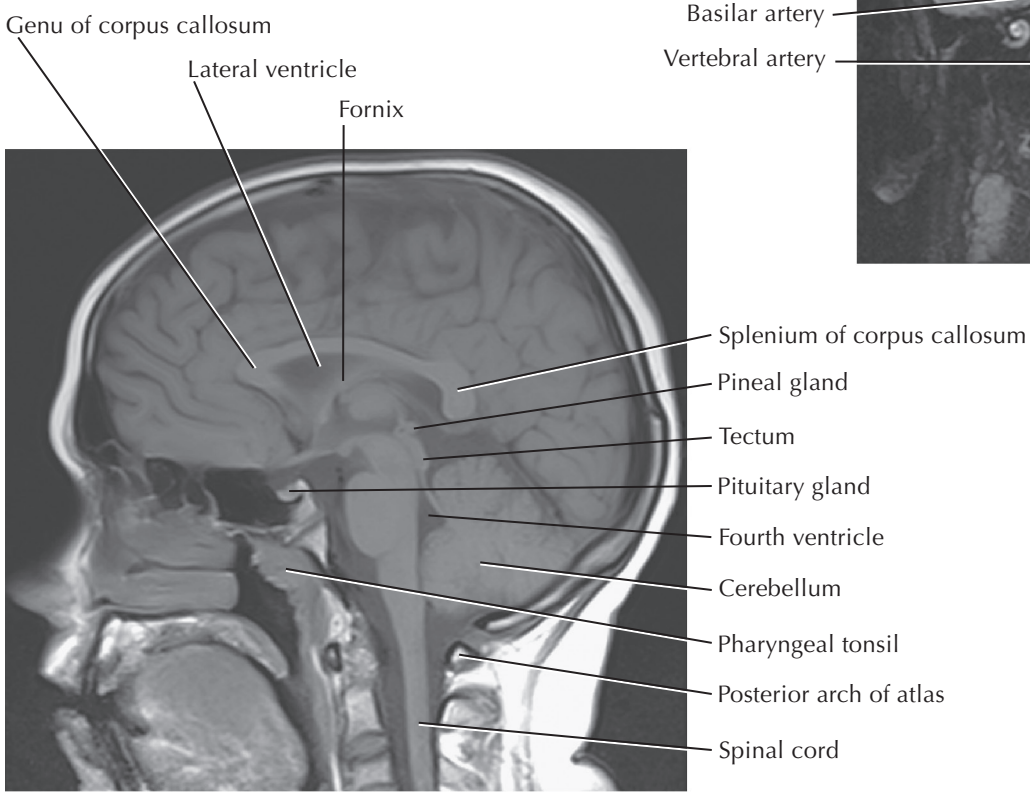

Hypothalamic vessels
Primary plexus of hypophyseal portal system
Superior hypophyseal artery
Long hypophyseal portal veins
Artery of trabecula
Short hypophyseal portal veins
Trabecula (fibrous tissue)
Efferent hypophyseal vein to cavernous sinus
Efferent hypophyseal vein to cavernous sinus
Secondary plexus of hypophyseal portal system
Neurohypophysis (posterior lobe of pituitary gland)
Capillary plexus of infundibular process
Adenohypophysis (anterior lobe of pituitary gland)
Efferent hypophyseal vein to cavernous sinus
Inferior hypophyseal artery
Efferent hypophyseal veins to cavernous sinus

Bridging vein
Superior sagittal sinus
Internal cerebral vein
Great cerebral vein (of Galen)
Straight sinus
Transverse sinus
Sigmoid sinus
Internal jugular vein

Anterior cerebral artery
Anterior communicating artery
Middle cerebral artery
Posterior communicating artery
Posterior cerebral artery
Basilar artery
Internal carotid artery
Vertebral artery


Subarachnoid space
Gray matter
Longitudinal fissure
White matter
Anterior cerebral artery
Third ventricle
Temporal lobe
Red nucleus
Midbrain
Cerebral aqueduct
Quadrigeminal cistern
Cerebellum


Superior sagittal sinus
Corpus callosum
Head of caudate
Lateral ventricle
Third ventricle
Pons
Basilar artery
Vertebral artery


Genu of corpus callosum
Lateral ventricle
Fornix
Splenium of corpus callosum
Pineal gland
Tectum
Pituitary gland
Fourth ventricle
Cerebellum
Pharyngeal tonsil
Posterior arch of atlas
Spinal cord

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Auricularis anterior	Temporal fascia, epicranial aponeurosis	Anterior part of medial surface of helix of ear	Posterior auricular and temporal branches of facial nerve	Elevates and draws ear forward	Auricular branch of posterior auricular artery, parietal branch of superficial temporal artery	External ear
Auricularis posterior	Base of mastoid process	Lower part of cranial surface of auricle	Posterior auricular and temporal branches of facial nerve	Retracts and elevates ear	Auricular branch of posterior auricular artery, parietal branch of superficial temporal artery	External ear
Auricularis superior	Temporal fascia, epicranial aponeurosis	Upper part of medial surface of auricle	Posterior auricular and temporal branches of facial nerve	Retracts and elevates ear	Auricular branch of posterior auricular artery, parietal branch of superficial temporal artery	External ear
Buccinator	Posterior portion of alveolar process of maxilla and mandible opposite sockets of molar teeth, anterior border of pterygomandibular raphe	Angle of mouth	Buccal branches of facial nerve	Compresses cheeks, expels air between lips, aids in mastication	Muscular branches of facial artery, buccal branch of maxillary artery	Facial expression
Ciliary	Corneoscleral junction	Ciliary body	Parasympathetic fibers via short ciliary nerves (CN III)	Constricts ciliary body and lens rounds up (accommodation)	Ophthalmic artery	Intrinsic eye
Corrugator supercilii	Medial part of supra-orbital margin	Skin of medial half of eyebrow	Zygomatic and temporal branches of facial nerve	Draws eyebrows downward and medially, produces wrinkles in frowning	Zygomatic and anterior branches of superficial temporal artery	Facial expression
Cricothyroid	Anterior cricoid cartilage	Inferior border of thyroid cartilage and its inferior horn	External branch of superior laryngeal nerve	Lengthens and tenses vocal ligaments	Superior and inferior thyroid arteries	Laryngeal
Depressor anguli oris	Continuous with platysma on oblique line of mandible	Angle of mouth into orbicularis and skin	Mandibular and buccal branches of facial nerve	Depresses angle of mouth	Inferior labial branch of facial artery	Facial expression
Depressor labii inferioris	Lateral surface of mandible between symphysis and mental foramen deep to depressor anguli oris	Skin to lower lip, mingling with orbicularis oris, medial fibers joining those of opposite side	Mandibular and buccal branches of facial nerve	Depresses lower lip and draws it lateralward	Inferior labial branch of facial artery	Facial expression
Depressor septi nasi	Incisive fossa of maxilla	Septum and posterior part of ala of nose	Zygomatic and buccal branches of facial nerve	Narrows nostril, draws septum downward	Superior labial branch of facial artery	Facial expression
Digastric	*Anterior belly:* digastric fossa of mandible *Posterior belly*: mastoid notch of temporal bone	Intermediate tendon attached to body of hyoid	*Anterior belly:* nerve to mylohyoid *Posterior belly:* facial nerve	Raises hyoid bone and base of tongue, steadies hyoid bone, opens mouth by lowering mandible	*Anterior belly*: branches of submental artery *Posterior belly:* muscular branches of posterior auricular artery, muscular branches of occipital artery	Suprahyoid
Dilator pupillae	Radial fibers in iris	Blends with sphincter pupillae fibers	Sympathetic fibers from SCG	Dilates pupil	Ophthalmic artery	Intrinsic eye
Frontal belly of occipitofrontalis	Epicranial aponeurosis at level of coronal suture	Skin of frontal region, epicranial aponeurosis	Temporal branches of facial nerve	Wrinkles forehead skin, raises eyebrows	Frontal branch of superficial temporal artery	Facial expression

Variations in spinal nerve contributions to the innervation of muscles, their arterial supply, their attachments, and their actions are common themes in human anatomy. Therefore, expect differences between texts and realize that anatomical variation is normal.

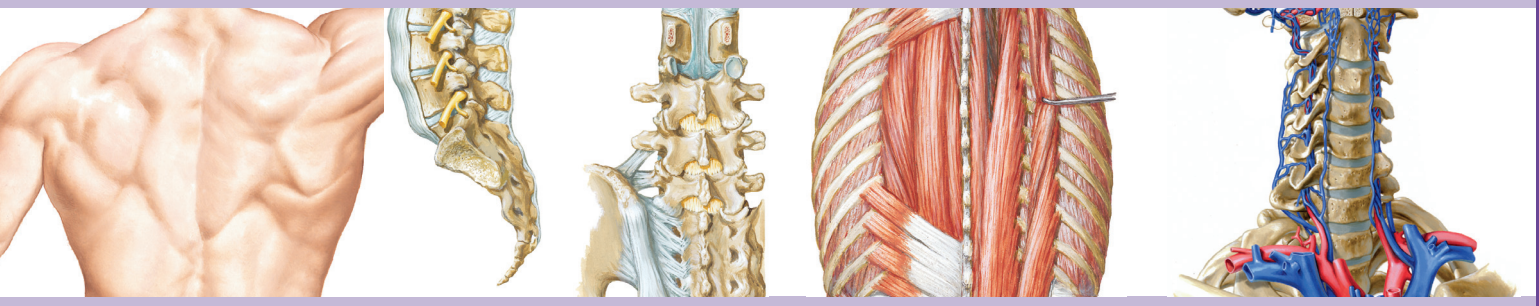
MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Genioglossus	Mental spine of mandible	Dorsum of tongue, hyoid bone	Hypoglossal nerve (CN XII)	Depresses and protrudes tongue	Sublingual and submental arteries	Extrinsic tongue
Geniohyoid	Inferior genial tubercle on back of symphysis of mandible	Anterior surface of body of hyoid bone	Branch of C1 through hypoglossal nerve (CN XII)	Elevates hyoid bone and depresses mandible	Sublingual branch of lingual artery	Suprahyoid
Hyoglossus	Body and greater horn of hyoid bone	Lateral and inferior aspect of tongue	Hypoglossal nerve (CN XII)	Depresses and retracts tongue	Sublingual and submental arteries	Extrinsic tongue
Inferior longitudinal muscle of tongue	Under surface of tongue between genioglossus and hyoglossus	Tip of tongue blending with styloglossus	Hypoglossal nerve (CN XII)	Shortens tongue, turns tip and sides downward	Deep lingual branch of lingual artery, branches from facial artery	Intrinsic tongue
Inferior oblique	Anterior floor of orbit lateral to nasolacrimal canal	Lateral sclera deep to lateral rectus	Oculomotor nerve (CN III), inferior division	Abducts, elevates, and laterally rotates eyeball	Ophthalmic artery	Extra-ocular
Inferior pharyngeal constrictor	Oblique line of thyroid cartilage and cricoid cartilage	Median raphe of pharynx	Vagus nerve via pharyngeal plexus	Constricts wall of pharynx during swallowing	Ascending pharyngeal artery, branches of superior thyroid artery	Circular pharyngeal
Inferior rectus	Common tendinous ring	Inferior aspect of eyeball, posterior to corneoscleral junction	Oculomotor nerve (CN III), inferior division	Depresses, adducts, and laterally rotates eyeball	Ophthalmic artery	Extra-ocular
Lateral crico-arytenoid	Arch of cricoid cartilage	Muscular process of arytenoid cartilage	Recurrent laryngeal nerve	Adducts vocal folds	Superior and inferior thyroid arteries	Laryngeal
Lateral pterygoid	*Superior head:* infratemporal surface of greater wing of sphenoid *Inferior head:* lateral pterygoid plate	Pterygoid fovea, capsule of temporomandibular joint, articular disc	Mandibular nerve ($CN V_3$), muscular branches from anterior division	*Bilaterally:* protrude mandible *Unilaterally and alternately:* produces side-to-side grinding	Muscular branches of maxillary artery	Mastication
Lateral rectus	Common tendinous ring	Lateral aspect of eyeball, posterior to corneoscleral junction	Abducent nerve (CN VI)	Abducts eyeball	Ophthalmic artery	Extra-ocular
Levator anguli oris	Canine fossa of maxilla immediately below infra-orbital foramen and under cover of zygomatic head of levator labii superioris	Angle of mouth; fibers intermingle with orbicularis oris, depressor anguli oris, zygomaticus	Zygomatic and buccal branches of facial nerve	Elevates angle of mouth	Superior labial branch of facial artery	Facial expression
Levator labii superioris alaeque nasi	*Angular head:* upper part of frontal process of maxilla *Infra-orbital head:* orbit above infra-orbital foramen *Zygomatic head:* malar surface of zygomatic bone	*Angular head:* into greater alar cartilage, skin of nose, lateral upper lip *Infra-orbital head:* into muscular substance of upper lip between angular head and caninus *Zygomatic head:* into skin of nasolabial groove and upper lip	Zygomatic and buccal branches of facial nerve	*Angular head:* elevates upper lip and dilates nostril *Infra-orbital head:* raises angle of mouth *Zygomatic head*: elevates upper lip laterally	Superior labial branch and angular branches of facial artery	Facial expression

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Levator labii superioris	Maxilla above infra-orbital foramen	Skin of upper lip	Zygomatic and buccal branches of facial nerve	Elevates upper lip, dilates nares	Superior labial artery and angular branches of facial artery	Facial expression
Levator palpebrae superioris	Lesser wing of sphenoid, anterior to optic canal	Superior tarsal plate	Oculomotor nerve (CN III), superior division	Raises upper eyelid	Ophthalmic artery	Extra-ocular; eyelid
Levator veli palatini	Temporal bone (petrous portion)	Palatine aponeurosis	Vagus nerve via pharyngeal plexus	Elevates soft palate during swallowing	Ascending palatine artery branch of facial artery, descending palatine artery branch of maxillary artery	Palatal
Longus capitis	Anterior tubercles of transverse processes of C3–C6	Inferior surface of basilar part of occipital bone	Ventral rami of cervical nerves (C1–C4)	Flexes and assists in rotating cervical vertebrae and head	Ascending cervical branch of inferior thyroid artery, ascending pharyngeal artery, muscular branches of vertebral artery	Prevertebral
Longus colli	*Vertical portion:* C5–T3 vertebrae *Inferior oblique portion:* T1–T3 vertebrae *Superior oblique portion*: anterior tubercles of transverse processes of C3–C5 vertebrae	*Vertical portion:* into C2–C4 vertebrae *Inferior oblique portion* on anterior tubercles of transverse processes of C5–C6 vertebrae *Superior oblique portion:* tubercle of anterior arch of atlas	Ventral primary rami of cervical nerves (C2–C8)	*Bilaterally*: flex and assist in rotating cervical vertebrae and head *Unilaterally:* flexes vertebral column laterally	Prevertebral branches of ascending pharyngeal artery, muscular branches of ascending cervical and vertebral arteries	Prevertebral
Masseter	Zygomatic arch	Ramus of mandible, coronoid process	Mandibular nerve (CN V_3), via masseteric nerve	Elevates and protrudes mandible; deep fibers retrude it	Transverse facial artery; masseteric branch of maxillary and facial arteries	Mastication
Medial pterygoid	Medial surface of lateral plate of pterygoid, pyramidal process of palatine bone, maxillary tuberosity	Medial surface of ramus and angle of mandible inferior to mandibular foramen	Mandibular nerve (V_3), nerve to medial pterygoid	*Bilaterally:* protrude and elevate mandible *Unilaterally and alternately:* produces side-to-side movements	Facial and maxillary arteries	Mastication
Medial rectus	Common tendinous ring	Medial aspect of eyeball, posterior to corneoscleral junction	Oculomotor nerve (CN III), inferior division	Adducts eyeball	Ophthalmic artery	Extra-ocular
Mentalis	Incisive fossa of mandible	Skin of chin	Mandibular branch of facial nerve	Raises and protrudes lower lip	Inferior labial branch of facial artery	Facial expression
Middle pharyngeal constrictor	Stylohyoid ligament and horns of hyoid bone	Median raphe of pharynx	Vagus nerve via pharyngeal plexus	Constricts wall of pharynx during swallowing	Ascending pharyngeal artery, ascending palatine and tonsillar branches of facial artery, dorsal lingual branches of lingual artery	Circular pharyngeal
Mylohyoid	Mylohyoid line of mandible	Median raphe and body of hyoid bone	Nerve to mylohyoid nerve (branch of trigeminal nerve)	Elevates hyoid bone, base of tongue, floor of mouth; depresses mandible	Sublingual branch of lingual artery, submental branch of facial artery	Suprahyoid

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Nasalis	Canine eminence above and lateral to incisive fossa of maxilla	Aponeurosis on nasal cartilages	Zygomatic and buccal branches of facial nerve	Draws ala of nose toward septum, compresses nostrils; alar part opens nostrils	Superior labial, septal, and lateral nasal branches of facial artery	Facial expression
Occipital belly (occipitalis) of epicranius	Lateral 2/3 of superior nuchal line and mastoid process	Skin of occipital region, epicranial aponeurosis	Posterior auricular branches of facial nerve	Moves scalp backward	Occipital branch of posterior auricular artery, descending branch of occipital artery	Facial expression
Omohyoid	*Inferior belly:* from upper border of scapula and suprascapular ligament, ending in tendon under sternocleidomastoid muscle *Superior belly:* from this tendon	*Inferior belly:* to intermediate tendon *Superior belly:* to body of hyoid bone	Ansa cervicalis	Steadies hyoid bone and depresses hyoid	Hyoid branch of lingual artery, sternocleidomastoid branch of superior thyroid artery	Infrahyoid
Orbicularis oculi	Medial orbital margin, palpebral ligament, lacrimal bone	Skin around orbit, palpebral ligament, upper and lower eyelids	Facial nerve (CN VII)	Closes eyelids	Facial and superficial temporal arteries	Facial expression
Orbicularis oris	Maxilla above incisor teeth	Skin around lips	Zygomatic, buccal, and mandibular branches of facial nerve	Compression, contraction, and protrusion of lips	Inferior and superior labial branches of facial artery	Facial expression
Palatoglossus	Palatine aponeurosis of soft palate	Lateral aspect of tongue	Vagus nerve via pharyngeal plexus	Elevates posterior tongue, depresses palate	Ascending pharyngeal arteries, palatine branches of facial and maxillary arteries	Palatal
Palatopharyngeus	Hard palate, superior palatine aponeurosis	Lateral pharyngeal wall	Vagus nerve via pharyngeal plexus	Tenses soft palate; pulls walls of pharynx superiorly, anteriorly, and medially during swallowing	Ascending palatine artery branch of facial artery, descending palatine artery branch of maxillary artery	Longitudinal pharyngeal
Platysma	Skin below clavicle, upper thorax	Mandible, oral muscles	Facial nerve	Tenses skin of neck	Submental and suprascapular arteries	Facial expression
Posterior crico-arytenoid	Posterior surface of lamina of cricoid cartilage	Muscular process of arytenoid cartilage	Recurrent laryngeal nerve	Abducts vocal folds	Superior and inferior thyroid arteries	Laryngeal
Procerus	Fascia covering lower parts of nasal bone and upper part of lateral nasal cartilage	Skin between and above eyebrow	Temporal and zygomatic branches of facial nerve	Draws down medial angle of eyebrows, produces transverse wrinkles over bridge of nose	Angular and lateral nasal branches of facial artery	Facial expression
Rectus capitis anterior	Lateral mass of atlas	Base of occipital bone in front of foramen magnum	Ventral rami of cervical nerves (C1–C2)	Flexes head	Muscular branches of vertebral artery, ascending pharyngeal artery	Prevertebral
Rectus capitis lateralis	Upper surface of transverse process of atlas	Inferior surface of jugular process of occipital bone	Ventral rami of cervical nerves (C1–C2)	Flexes head laterally to same side	Muscular branches of vertebral artery, occipital artery, ascending pharyngeal artery	Prevertebral
Risorius	Fascia over masseter superficial to platysma	Skin at angle of mouth	Zygomatic and buccal branches of facial nerve	Retracts angle of mouth	Superior labial branch of facial artery	Facial expression
Salpingopharyngeus	Pharyngotympanic (auditory, eustachian) tube	Side of pharyngeal wall	Vagus nerve via pharyngeal plexus	Elevates pharynx and larynx during swallowing and speaking	Pharyngeal branch of ascending pharyngeal artery	Longitudinal pharyngeal

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Scalene (anterior)	Anterior tubercles of transverse processes of C3–C6	Scalene tubercle on 1st rib	Anterior rami of cervical nerves (C5–C8)	Elevates 1st rib, bends neck	Ascending cervical branch of inferior thyroid artery	Prevertebral
Scalene (medius)	Posterior tubercles of transverse processes of C2–C7	Upper surface of 1st rib (behind subclavian groove)	Anterior rami of cervical nerves (C3–C7)	Elevates 1st rib, bends neck	Muscular branches of ascending cervical artery	Prevertebral
Scalene (posterior)	Posterior tubercles of transverse processes of C4–C6	Outer surface of 2nd rib (behind attachment of serratus anterior)	Anterior rami of lower four cervical nerves	Elevates 2nd rib, bends neck	Muscular branches of ascending cervical division of inferior thyroid artery, superficial branch of transverse cervical artery	Prevertebral
Sphincter pupillae	Circular smooth muscle of iris that passes around pupil	Blends with dilator pupillae fibers	Parasympathetic fibers via oculomotor nerve (CN III)	Constricts pupil	Ophthalmic artery	Intrinsic eye
Stapedius	Pyramidal eminence of temporal bone	Stapes	Facial nerve	Pulls stapes posteriorly to lessen oscillation of tympanic membrane	Posterior auricular, anterior tympanic, and middle meningeal arteries	Middle ear
Sternocleidomastoid	*Sternal head:* anterior surface of manubrium *Clavicular head:* upper surface of medial 1/3 of clavicle	Lateral surface of mastoid process; lateral half of superior nuchal line of occipital bone	Accessory nerve (CN XI)	*Bilaterally:* flex head, raise thorax *Unilaterally:* turns face toward opposite side	Sternocleidomastoid branch of superior thyroid and occipital arteries, muscular branch of suprascapular artery, occipital branch of posterior auricular artery	Neck
Sternohyoid	Posterior surface of manubrium sterni, posterior sternoclavicular ligament, medial end of clavicle	Medial part of lower border of body of hyoid bone	Ansa cervicalis	Depresses larynx and hyoid bone, steadies hyoid bone	Sternocleidomastoid and hyoid branches of superior thyroid artery, hyoid branch of lingual artery	Infrahyoid
Sternothyroid	Posterior surface of manubrium sterni below and deep to origin of sternohyoid, edge of first costal cartilage	Oblique line on lamina of thyroid cartilage	Ansa cervicalis	Depresses larynx and thyroid cartilage	Cricothyroid branch of superior thyroid artery	Infrahyoid
Styloglossus	Styloid process and stylohyoid ligament	Lateral and inferior aspect of tongue	Hypoglossal nerve (CN XII)	Retracts tongue and draws it up for swallowing	Sublingual artery	Extrinsic tongue
Stylohyoid	Posterior border of styloid process	Body of hyoid bone at junction with greater horn	Facial nerve	Elevates hyoid bone and base of tongue	Muscular branches of facial artery, muscular branches of occipital artery	Suprahyoid
Stylopharyngeus	Medial aspect of styloid process	Pharyngeal wall	Glossopharyngeal nerve (CN IX)	Elevates pharynx and larynx during swallowing and speaking	Ascending pharyngeal artery, ascending palatine and tonsillar branches of facial artery, dorsal branches of lingual artery	Longitudinal pharyngeal
Subclavius	Upper border of 1st rib and its cartilage	Inferior surface of middle third of clavicle	Nerve to subclavius	Anchors and depresses clavicle	Clavicular branch of thoraco-acromial artery	Neck
Superior longitudinal muscle of tongue	Submucous fibers at back of tongue	Tip of tongue; unites with muscle of opposite side	Hypoglossal nerve (CN XII)	Shortens tongue, turns tip and sides upward	Deep lingual branch of lingual artery, branches from facial artery	Intrinsic tongue
Superior oblique	Body of sphenoid (above optic foramen), medial to origin of superior rectus	Passes through trochlea, attaches to superior sclera between superior and lateral recti	Trochlear nerve (CN IV)	Abducts, depresses, and medially rotates eyeball	Ophthalmic artery	Extra-ocular

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Superior pharyngeal constrictor	Hamulus, pterygomandibular raphe, mylohyoid line of mandible	Median raphe of pharynx	Vagus nerve via pharyngeal plexus	Constricts wall of pharynx during swallowing	Ascending pharyngeal artery, ascending palatine and tonsillar branches of facial artery, dorsal branches of lingual artery	Circular pharyngeal
Superior rectus	Common tendinous ring	Superior aspect of eyeball, posterior to the corneoscleral junction	Oculomotor nerve (CN III), superior division	Elevates, adducts, and medially rotates eyeball	Ophthalmic artery	Extra-ocular
Temporalis	Floor of temporal fossa, deep temporal fascia	Coronoid process and ramus of mandible	Mandibular nerve (CN V_3),deep temporal nerves	Elevates mandible; posterior fibers retrude mandible	Superficial temporal and maxillary arteries, middle, anterior, and posterior deep temporal arteries	Mastication
Tensor tympani	Cartilage of pharyngotympanic (auditory, eustachian) tube	Handle of malleus	Mandibular branch of trigeminal nerve (CN V_3)	Tenses tympanic membrane by drawing it medially	Superior tympanic branch of middle meningeal division of maxillary artery	Middle ear
Tensor veli palatini	Scaphoid fossa of medial pterygoid plate, spine of sphenoid, pharyngotympanic (auditory, eustachian) tube	Palatine aponeurosis	Mandibular nerve	Tenses soft palate, opens pharyngotympanic (auditory, eustachian) tube during swallowing and yawning	Ascending palatine artery branch of facial artery, descending palatine artery branch of maxillary artery	Palatal
Thyro-arytenoid	Posterior aspect of thyroid cartilage	Muscular process of arytenoid cartilage	Recurrent laryngeal nerve	Shortens and relaxes vocal cords, sphincter of vestibule	Superior and inferior thyroid arteries	Laryngeal
Thyrohyoid	Oblique line on lamina of thyroid cartilage	Lower border of body and greater horn of hyoid bone	Thyrohyoid branch of C1 nerve via hypoglossal nerve (CN XII)	Depresses larynx and hyoid bone, elevates thyroid cartilage	Hyoid branch of superior thyroid artery	Infrahyoid
Transverse and oblique arytenoid	Arytenoid cartilage	Opposite arytenoid cartilage	Recurrent laryngeal nerve	Closes intercartilaginous portion of rima glottides	Superior and inferior thyroid arteries	Laryngeal
Transverse (tongue)	Median fibrous septum of tongue	Dorsum and sides of tongue	Hypoglossal nerve (CN XII)	Narrows and elongates tongue	Deep lingual branch of lingual artery, branches from facial artery	Intrinsic tongue
Uvular muscle	Nasal spine, palatine aponeurosis	Mucosa of uvula	Vagus nerve via pharyngeal plexus	Shortens, elevates, and retracts uvula	Ascending palatine artery branch of facial artery, descending palatine artery branch of maxillary artery	Palatal
Vertical (tongue)	Mucous membrane on dorsum of forepart of tongue	Fibers extend from dorsum to undersurface of tongue	Hypoglossal nerve (CN XII)	Flattens and broadens tongue	Deep lingual branch of lingual artery, branches from facial artery	Intrinsic tongue
Vocalis	Vocal process of arytenoid cartilage	Vocal ligament	Recurrent laryngeal nerve	Tenses anterior vocal ligament, relaxes posterior vocal ligament	Superior and inferior thyroid arteries	Laryngeal
Zygomaticus major	Zygomatic arch	Angle of mouth	Zygomatic and buccal branches of facial nerve	Draws angle of mouth backward and upward	Superior labial branch of facial artery	Facial expression
Zygomaticus minor	Zygomatic arch	Angle of mouth, upper lip	Zygomatic and buccal branches of facial nerve	Elevates upper lip	Superior labial branch of facial artery	Facial expression



Section

2 BACK AND SPINAL CORD

Topographic Anatomy
Plate 152

152 Back: Surface Anatomy

Bones and Ligaments
Plates 153–159

153 Vertebral Column
154 Thoracic Vertebrae
155 Lumbar Vertebrae
156 Vertebrae: Radiology
157 Sacrum and Coccyx
158 Vertebral Ligaments: Lumbosacral Region
159 Vertebral Ligaments: Lumbar Region

Spinal Cord
Plates 160–170

160 Spinal Cord and Ventral Rami in Situ
161 Relation of Spinal Nerve Roots to Vertebrae
162 Dermatomes
163 Sympathetic Nervous System: Schema
164 Parasympathetic Nervous System: Schema
165 Spinal Membranes and Nerve Roots
166 Spinal Nerve Origin: Cross Sections
167 Arteries of Spinal Cord: Schema
168 Arteries of Spinal Cord: Intrinsic Distribution
169 Veins of Spinal Cord and Vertebral Column
170 Veins of Vertebral Column: Vertebral Veins

Muscles and Nerves

Plates 171–175

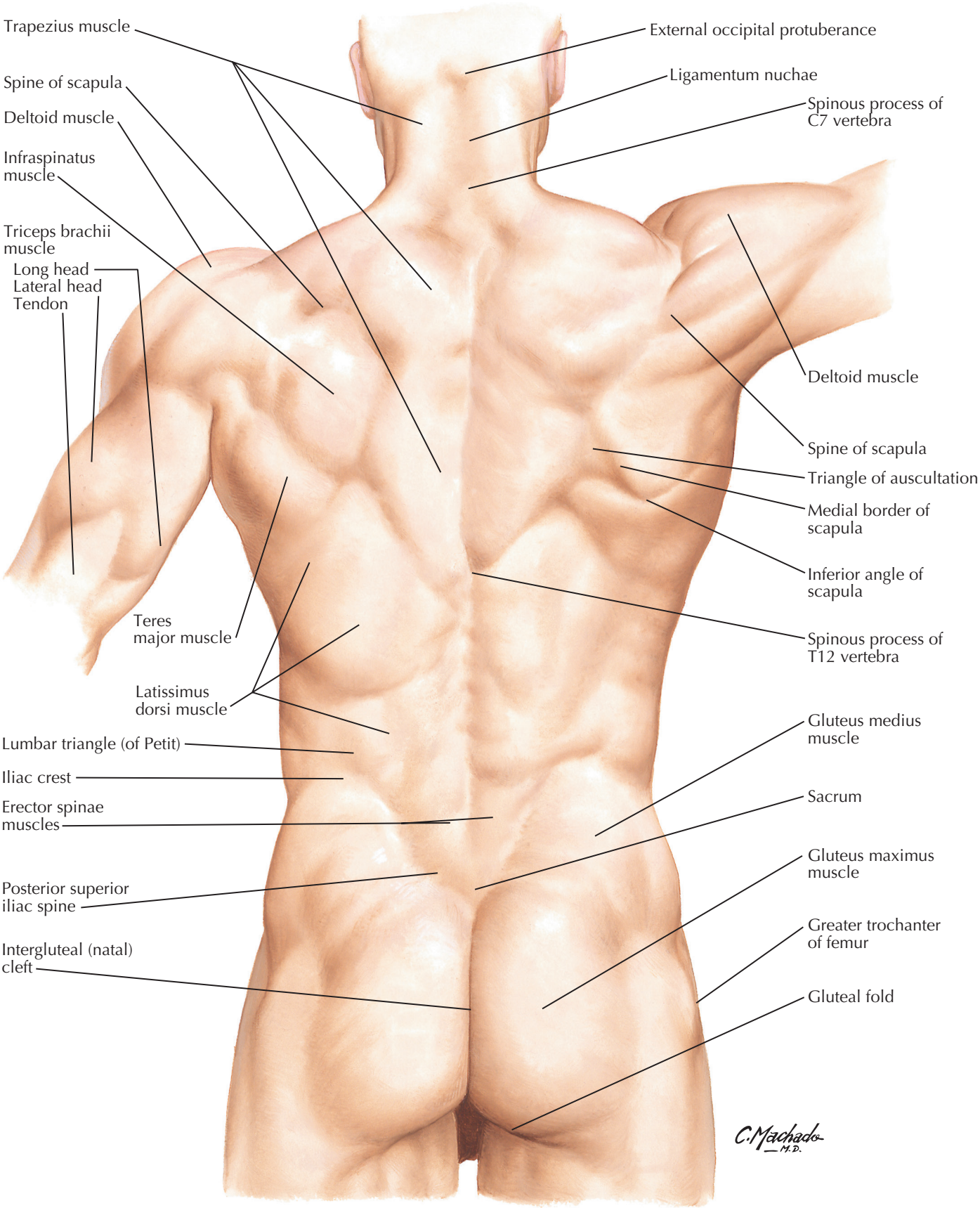
171 Muscles of Back: Superficial Layers
172 Muscles of Back: Intermediate Layers
173 Muscles of Back: Deep Layers
174 Nerves of Back
175 Suboccipital Triangle

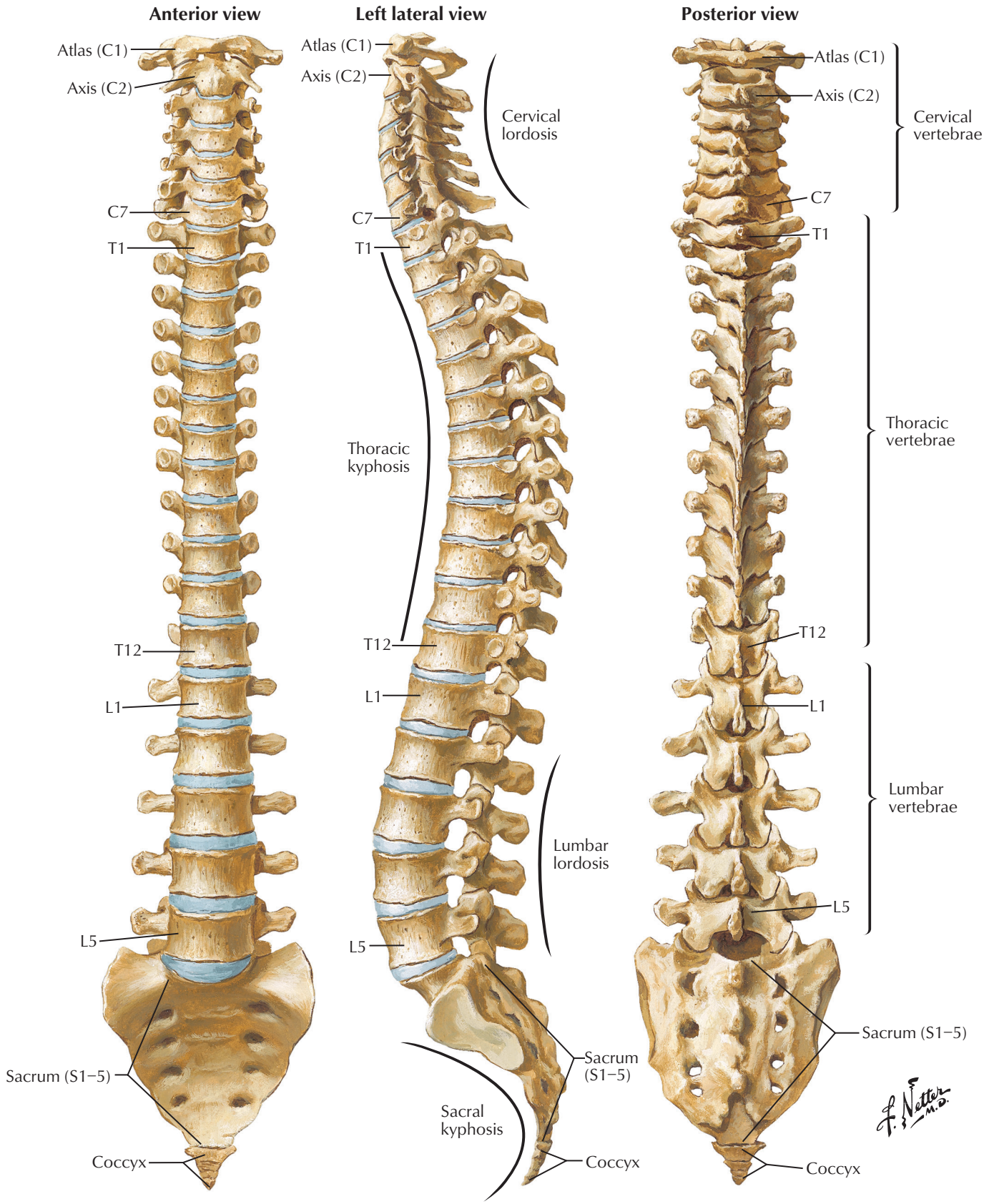
Cross-Sectional Anatomy

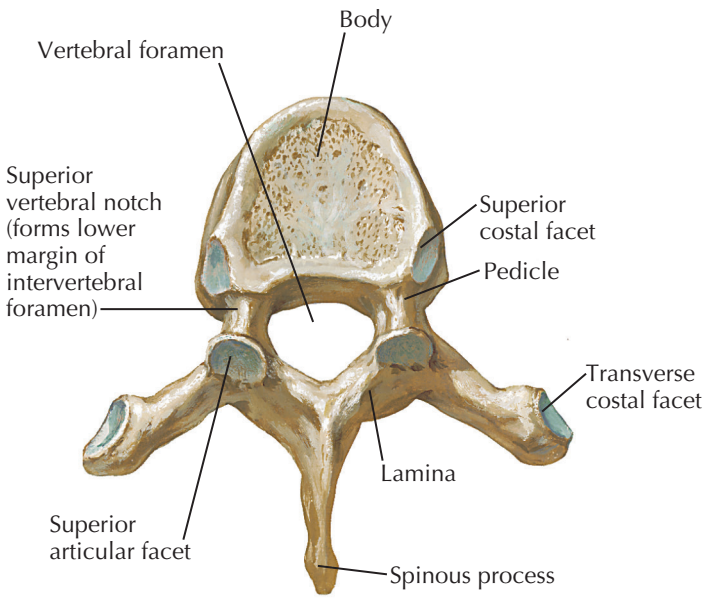
Plates 176–177

176 Lumbar Region of Back: Cross Section
177 Typical Thoracic Spinal Nerve: Cross Section

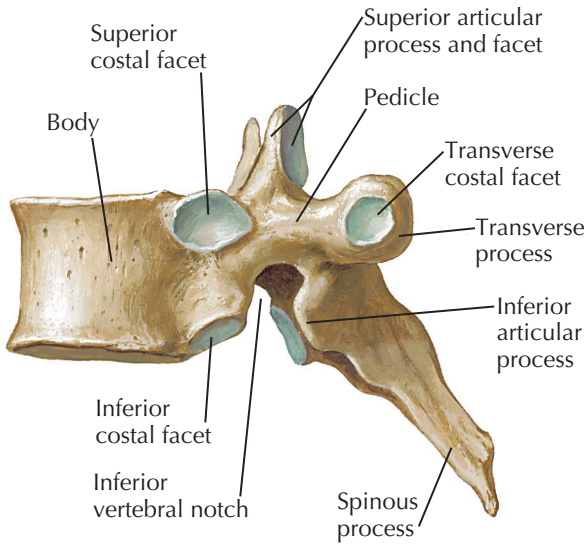
Muscle Tables


Trapezius muscle
Spine of scapula
Deltoid muscle
Infraspinatus muscle
Triceps brachii muscle
Long head
Lateral head
Tendon
Teres major muscle
Latissimus dorsi muscle
Lumbar triangle (of Petit)
Iliac crest
Erector spinae muscles
Posterior superior iliac spine
Intergluteal (natal) cleft
External occipital protuberance
Ligamentum nuchae
Spinous process of C7 vertebra
Deltoid muscle
Spine of scapula
Triangle of auscultation
Medial border of scapula
Inferior angle of scapula
Spinous process of T12 vertebra
Gluteus medius muscle
Sacrum
Gluteus maximus muscle
Greater trochanter of femur
Gluteal fold
C. Machado M.D.

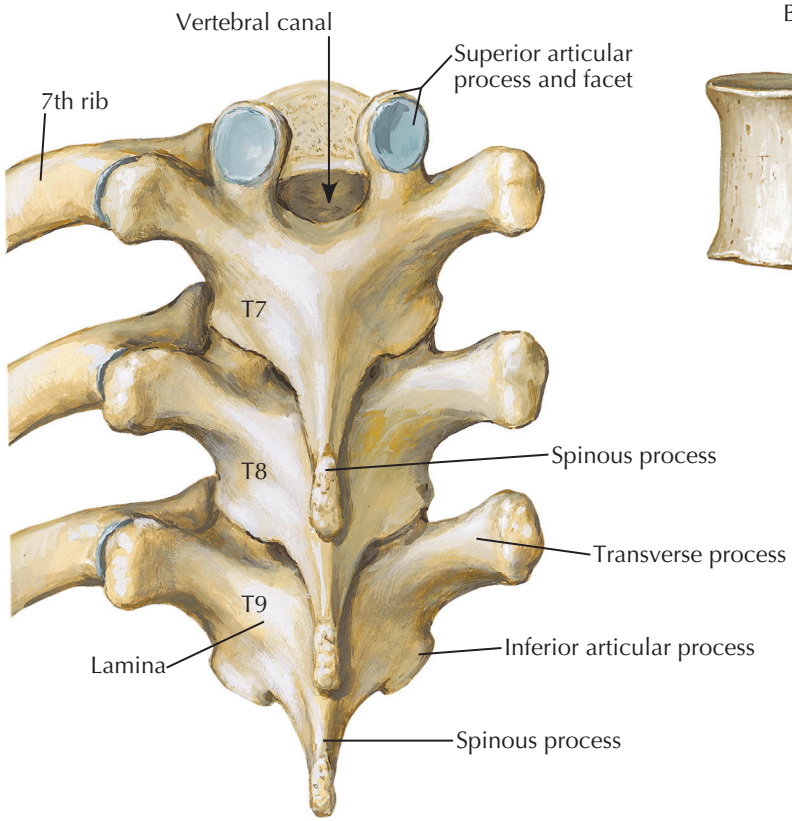

Anterior view
Atlas (C1)
Axis (C2)
C7
T1
T12
L1
L5
Sacrum (S1–5)
Coccyx
Left lateral view
Atlas (C1)
Axis (C2)
Cervical lordosis
C7
T1
Thoracic kyphosis
T12
L1
Lumbar lordosis
L5
Sacrum (S1–5)
Sacral kyphosis
Coccyx
Posterior view
Atlas (C1)
Axis (C2)
Cervical vertebrae
C7
T1
Thoracic vertebrae
T12
L1
Lumbar vertebrae
L5
Sacrum (S1–5)
Coccyx



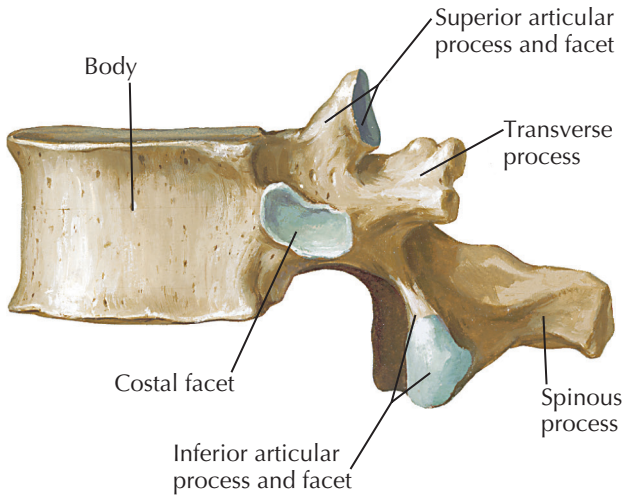
T6 vertebra: superior view



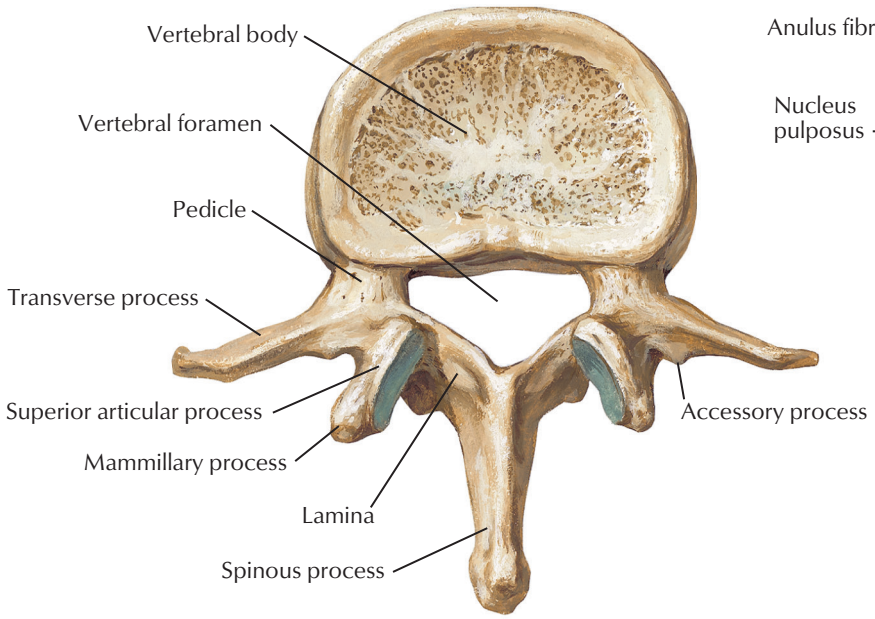
T6 vertebra: lateral view



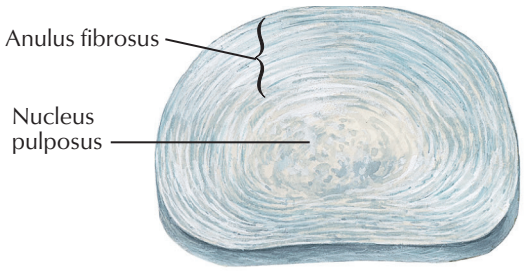
T7, T8, and T9 vertebrae: posterior view



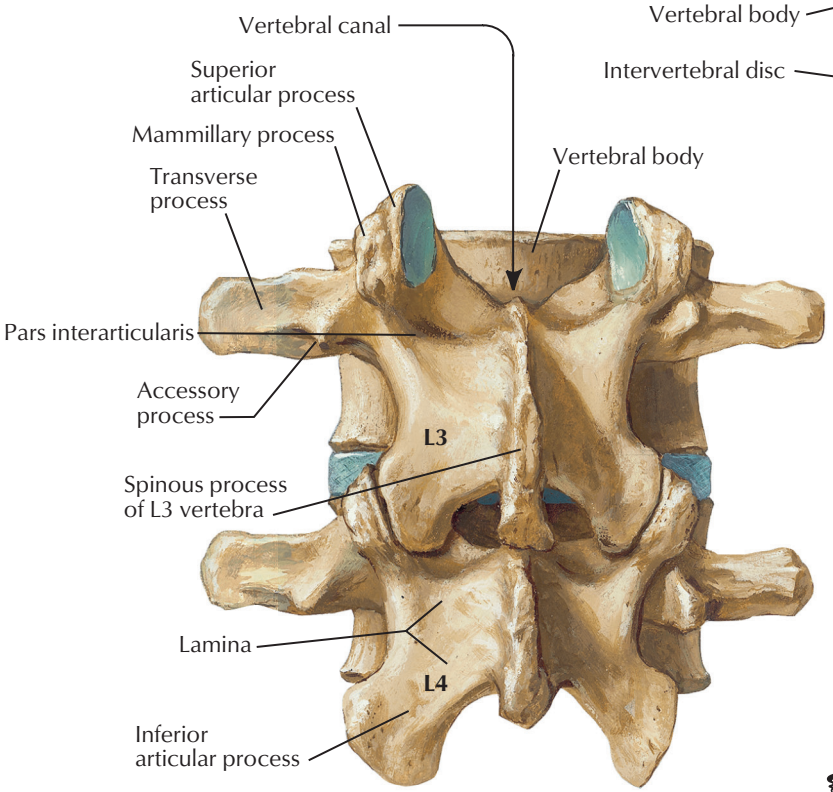
T12 vertebra: lateral view



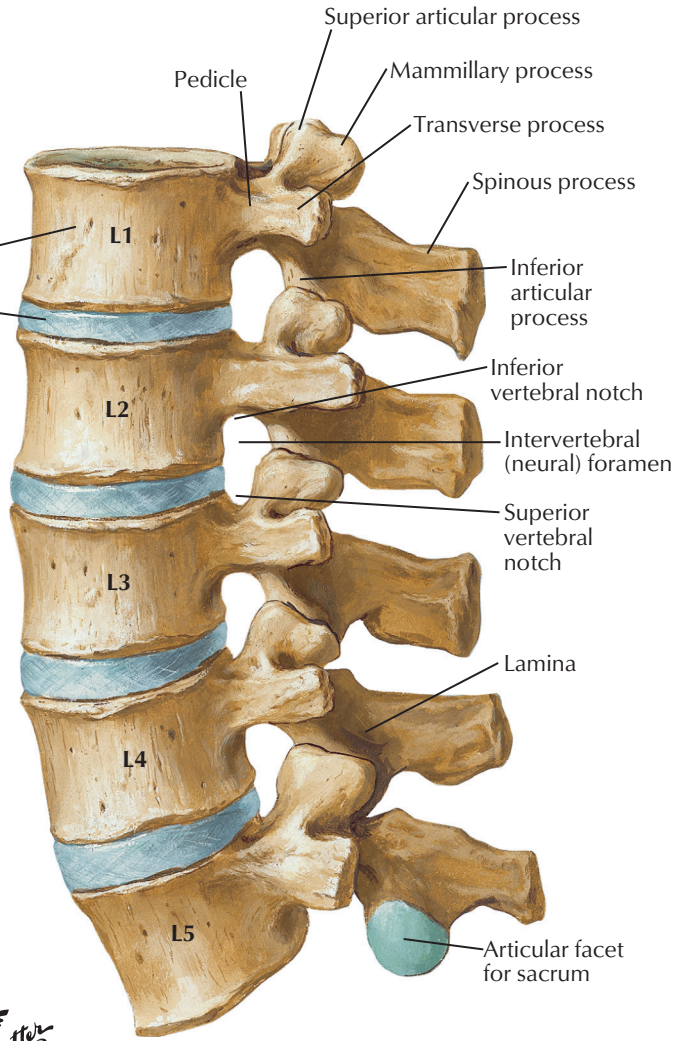
L2 vertebra: superior view



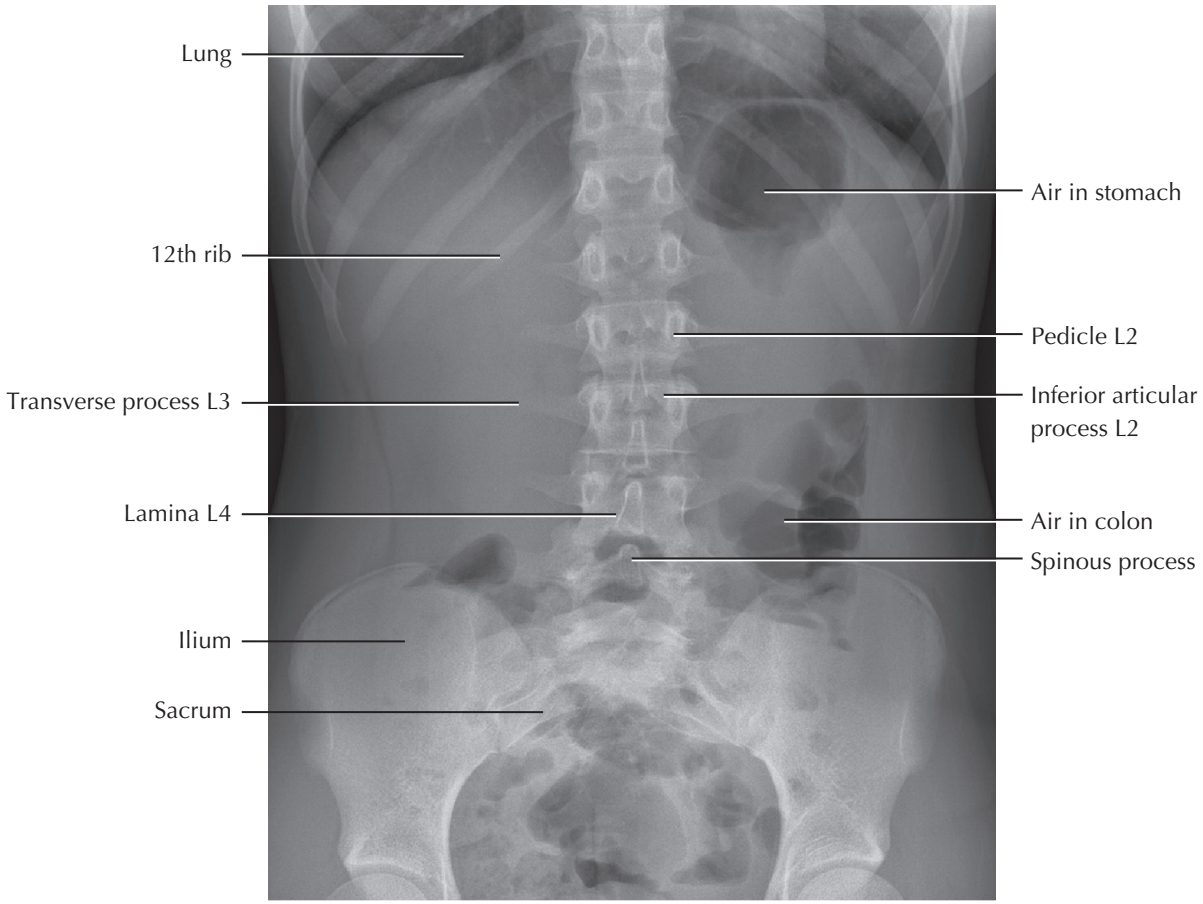
Intervertebral disc

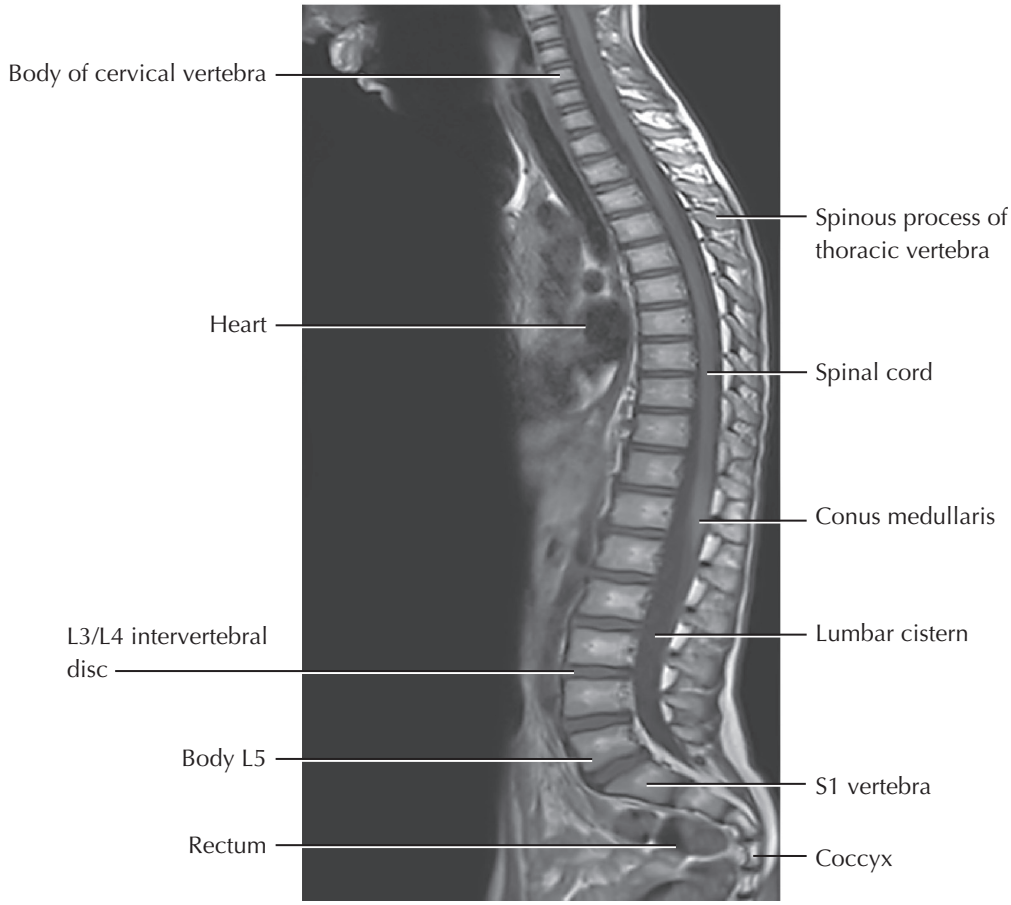


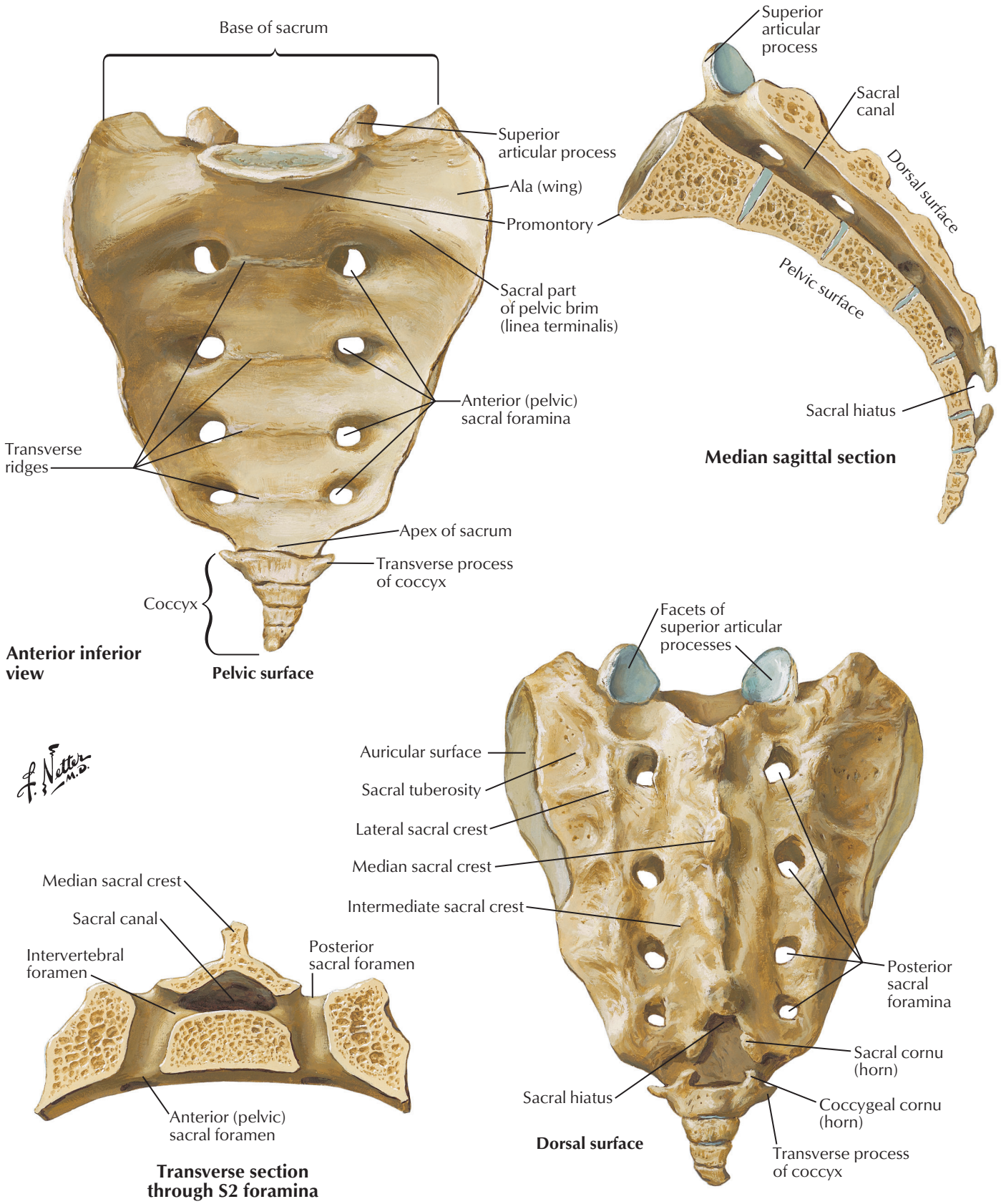
L3 and L4 vertebrae: posterior view

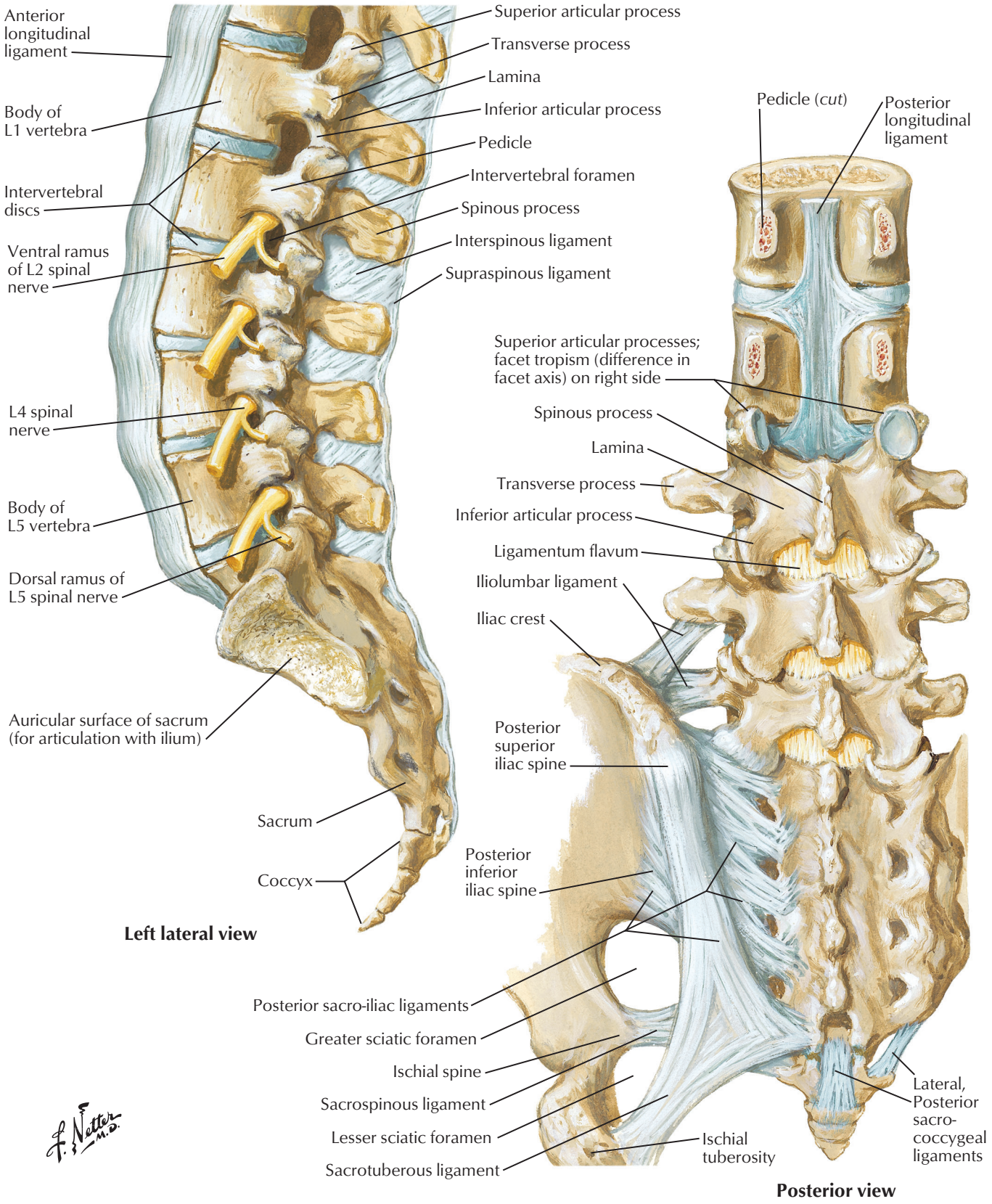


Lumbar vertebrae, articulated: left lateral view

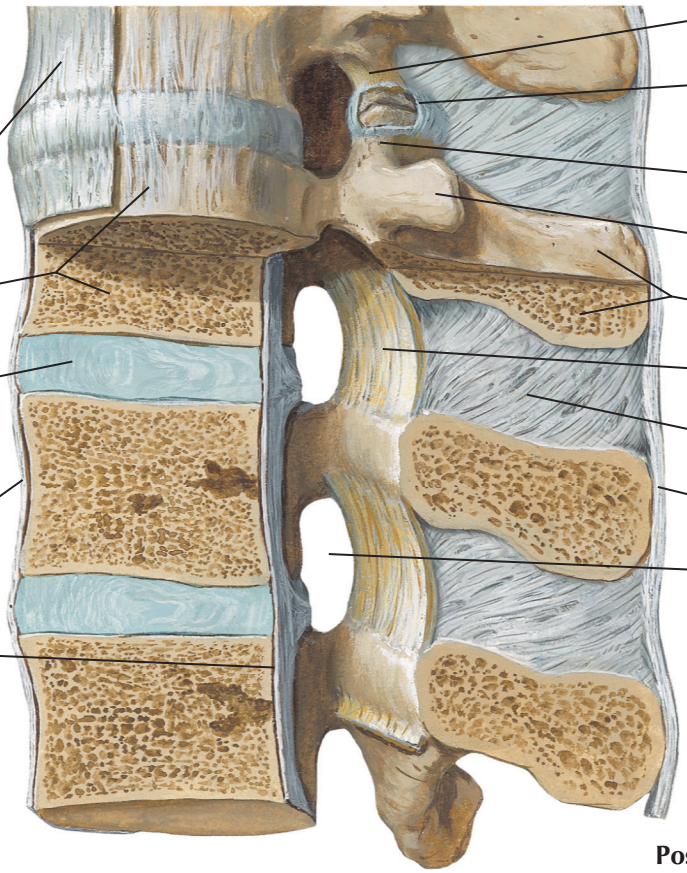

Lung
Air in stomach
12th rib
Pedicle L2
Transverse process L3
Inferior articular process L2
Lamina L4
Air in colon
Spinous process
Ilium
Sacrum

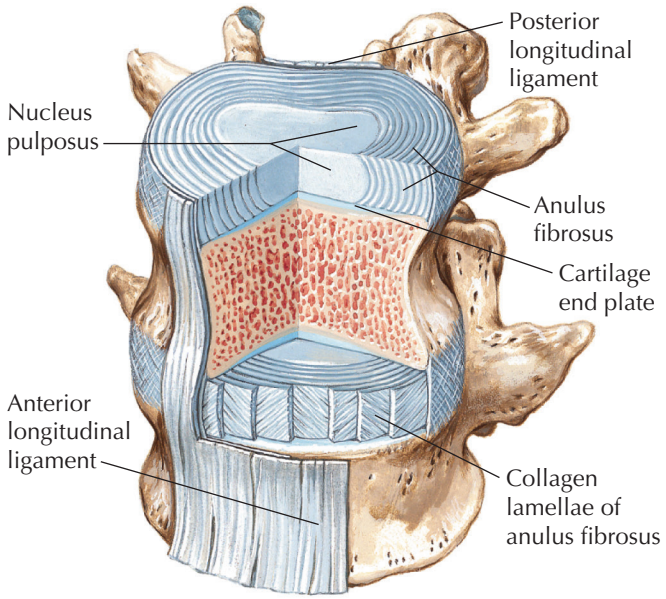

Body of cervical vertebra
Spinous process of thoracic vertebra
Heart
Spinal cord
Conus medullaris
L3/L4 intervertebral disc
Lumbar cistern
Body L5
S1 vertebra
Rectum
Coccyx


Base of sacrum
Superior articular process
Ala (wing)
Promontory
Sacral part of pelvic brim (linea terminalis)
Anterior (pelvic) sacral foramina
Transverse ridges
Apex of sacrum
Transverse process of coccyx
Coccyx
Anterior inferior view
Pelvic surface
Superior articular process
Sacral canal
Dorsal surface
Pelvic surface
Sacral hiatus
Median sagittal section
Facets of superior articular processes
Auricular surface
Sacral tuberosity
Lateral sacral crest
Median sacral crest
Intermediate sacral crest
Posterior sacral foramina
Sacral cornu (horn)
Sacral hiatus
Coccygeal cornu (horn)
Transverse process of coccyx
Dorsal surface
Posterior superior view
Median sacral crest
Sacral canal
Intervertebral foramen
Posterior sacral foramen
Anterior (pelvic) sacral foramen
Transverse section through S2 foramina


Anterior longitudinal ligament
Body of L1 vertebra
Intervertebral discs
Ventral ramus of L2 spinal nerve
L4 spinal nerve
Body of L5 vertebra
Dorsal ramus of L5 spinal nerve
Auricular surface of sacrum (for articulation with ilium)
Sacrum
Coccyx
Superior articular process
Transverse process
Lamina
Inferior articular process
Pedicle
Intervertebral foramen
Spinous process
Interspinous ligament
Supraspinous ligament
Left lateral view
Pedicle (cut)
Posterior longitudinal ligament
Superior articular processes; facet tropism (difference in facet axis) on right side
Spinous process
Lamina
Transverse process
Inferior articular process
Ligamentum flavum
Iliolumbar ligament
Iliac crest
Posterior superior iliac spine
Posterior inferior iliac spine
Posterior sacro-iliac ligaments
Greater sciatic foramen
Ischial spine
Sacrospinous ligament
Lesser sciatic foramen
Sacrotuberous ligament
Ischial tuberosity
Lateral, Posterior sacro-coccygeal ligaments
Posterior view

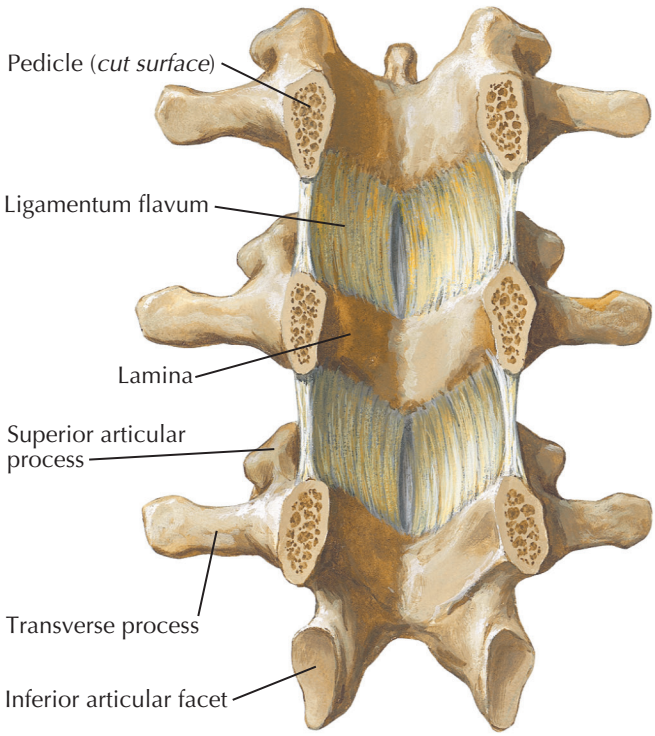
Left lateral view (*partially sectioned in median plane*)

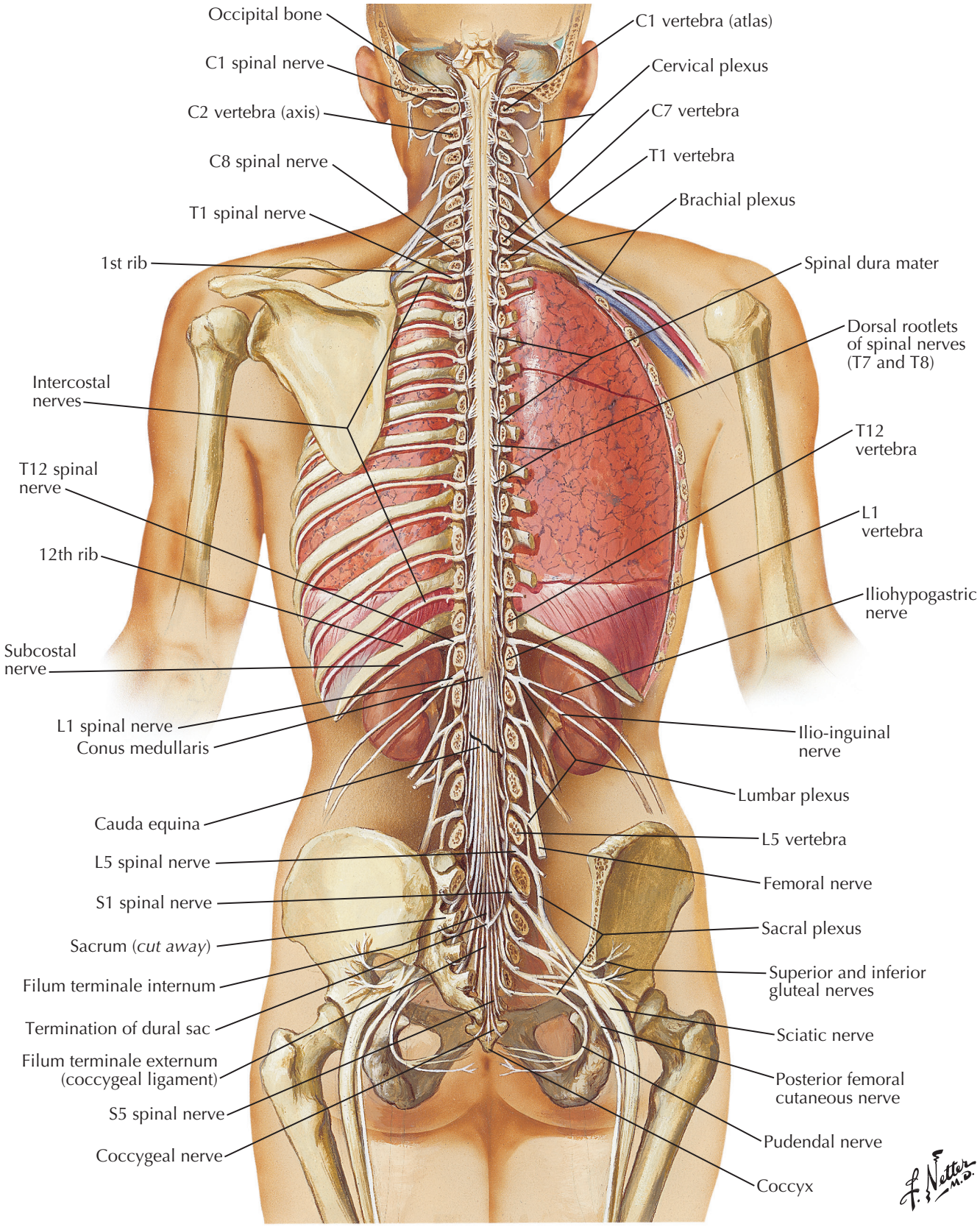




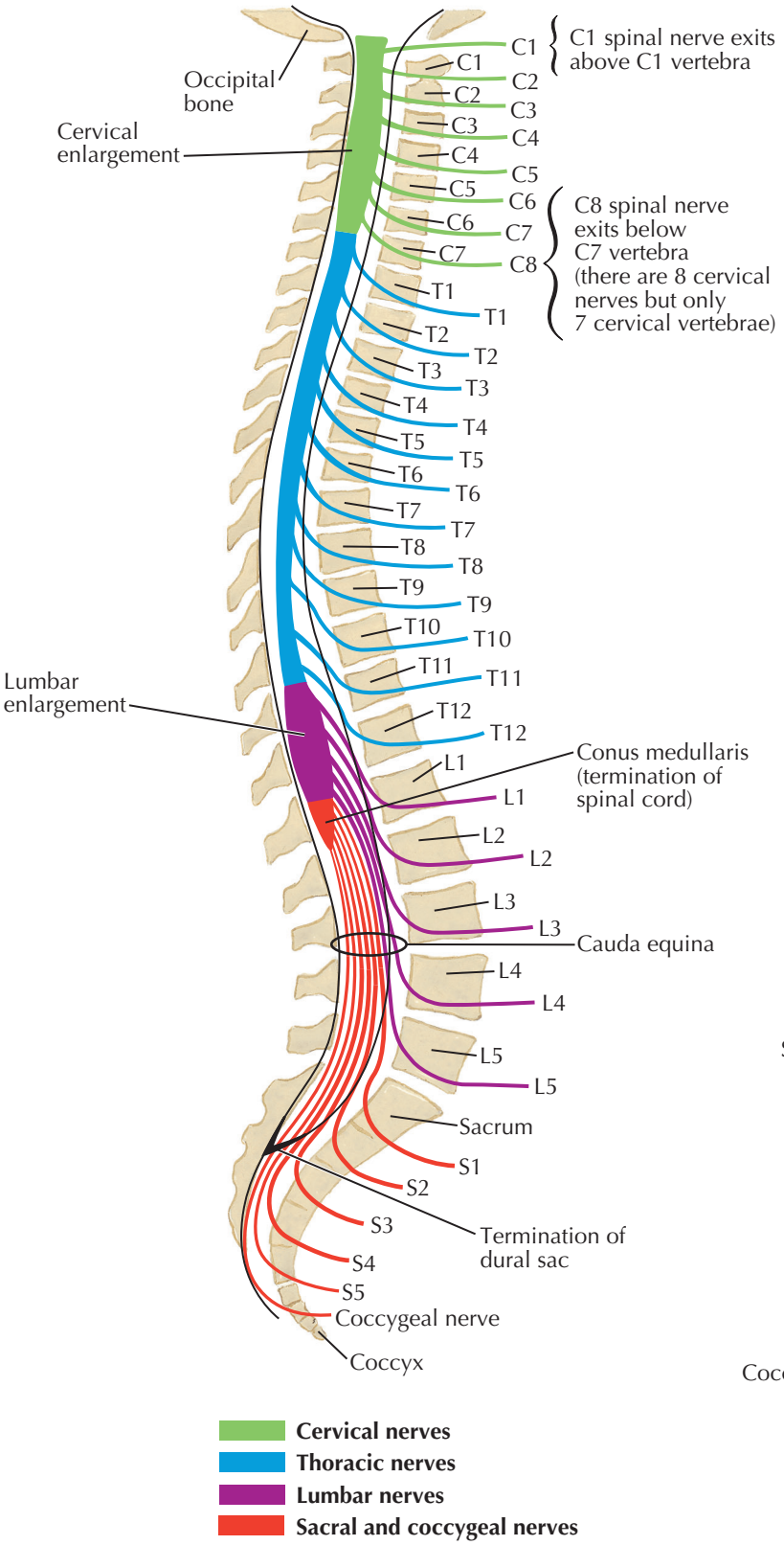
Intervertebral disc composed of central nuclear zone of collagen and hydrated proteoglycans surrounded by concentric lamellae of collagen fibers

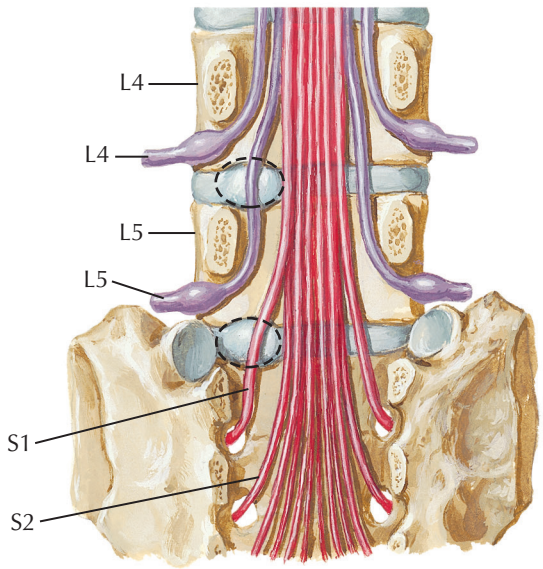
Posterior vertebral arches: anterior view



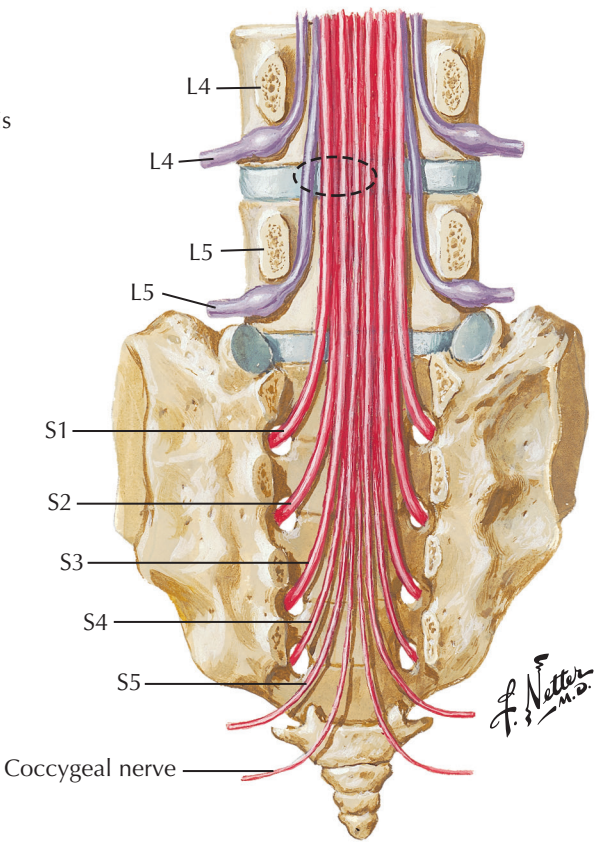

Occipital bone
C1 spinal nerve
C2 vertebra (axis)
C8 spinal nerve
T1 spinal nerve
1st rib
Intercostal nerves
T12 spinal nerve
12th rib
Subcostal nerve
L1 spinal nerve
Conus medullaris
Cauda equina
L5 spinal nerve
S1 spinal nerve
Sacrum (*cut away*)
Filum terminale internum
Termination of dural sac
Filum terminale externum (coccygeal ligament)
S5 spinal nerve
Coccygeal nerve
C1 vertebra (atlas)
Cervical plexus
C7 vertebra
T1 vertebra
Brachial plexus
Spinal dura mater
Dorsal rootlets of spinal nerves (T7 and T8)
T12 vertebra
L1 vertebra
Iliohypogastric nerve
Ilio-inguinal nerve
Lumbar plexus
L5 vertebra
Femoral nerve
Sacral plexus
Superior and inferior gluteal nerves
Sciatic nerve
Posterior femoral cutaneous nerve
Pudendal nerve
Coccyx
F. Netter M.D.

Relation of Spinal Nerve Roots to Vertebrae

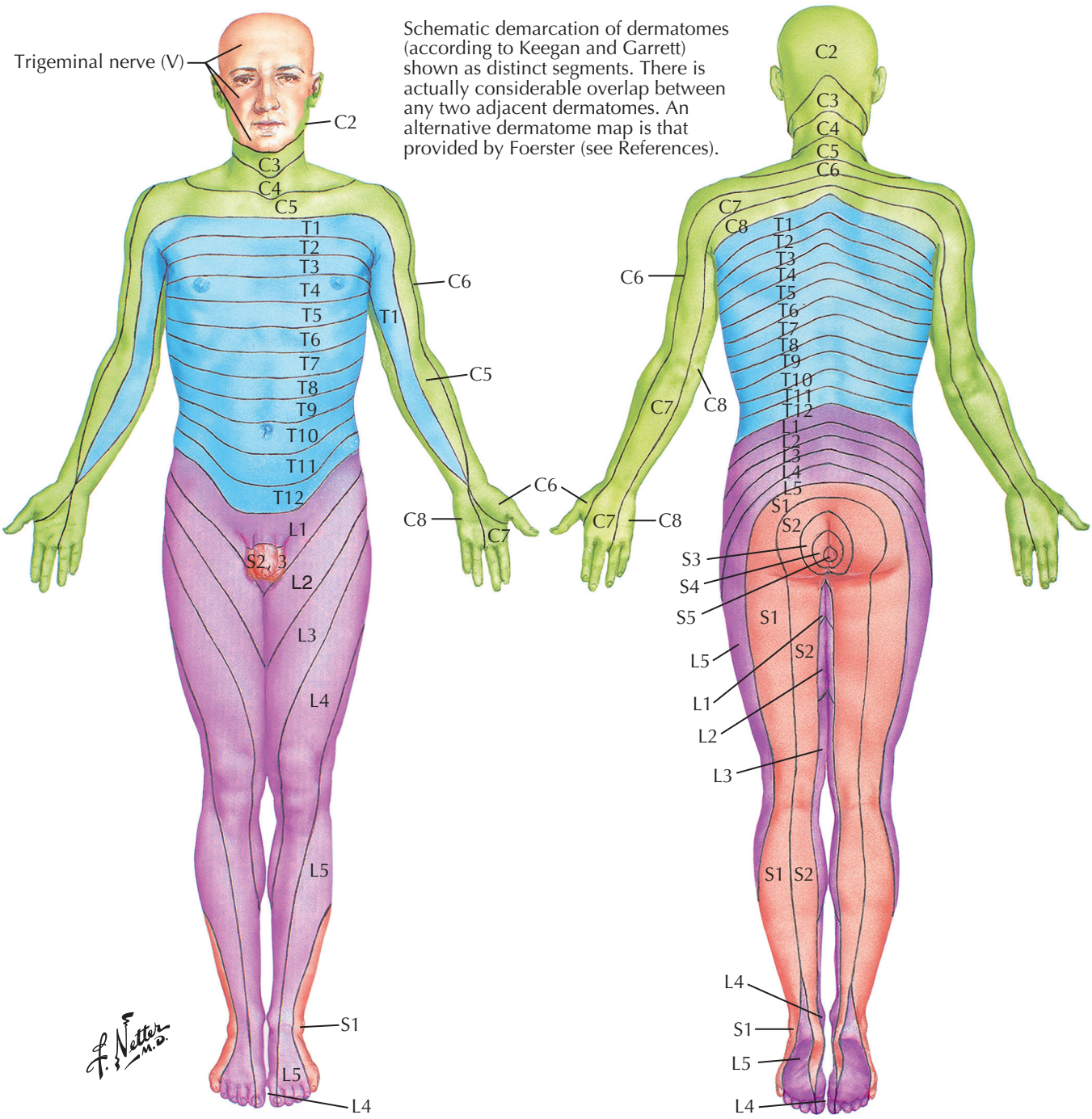




Lumbar disc protrusion (*dashed ovals*) does not usually affect nerve exiting above disc. Lateral protrusion at disc level L4–5 affects L5 spinal nerve, not L4 spinal nerve. Protrusion at disc level L5–S1 affects S1 spinal nerve, not L5 spinal nerve.



Medial protrusion at disc level L4–5 (*dashed oval*) rarely affects L4 spinal nerve but may affect L5 spinal nerve and sometimes S1–4 spinal nerves.

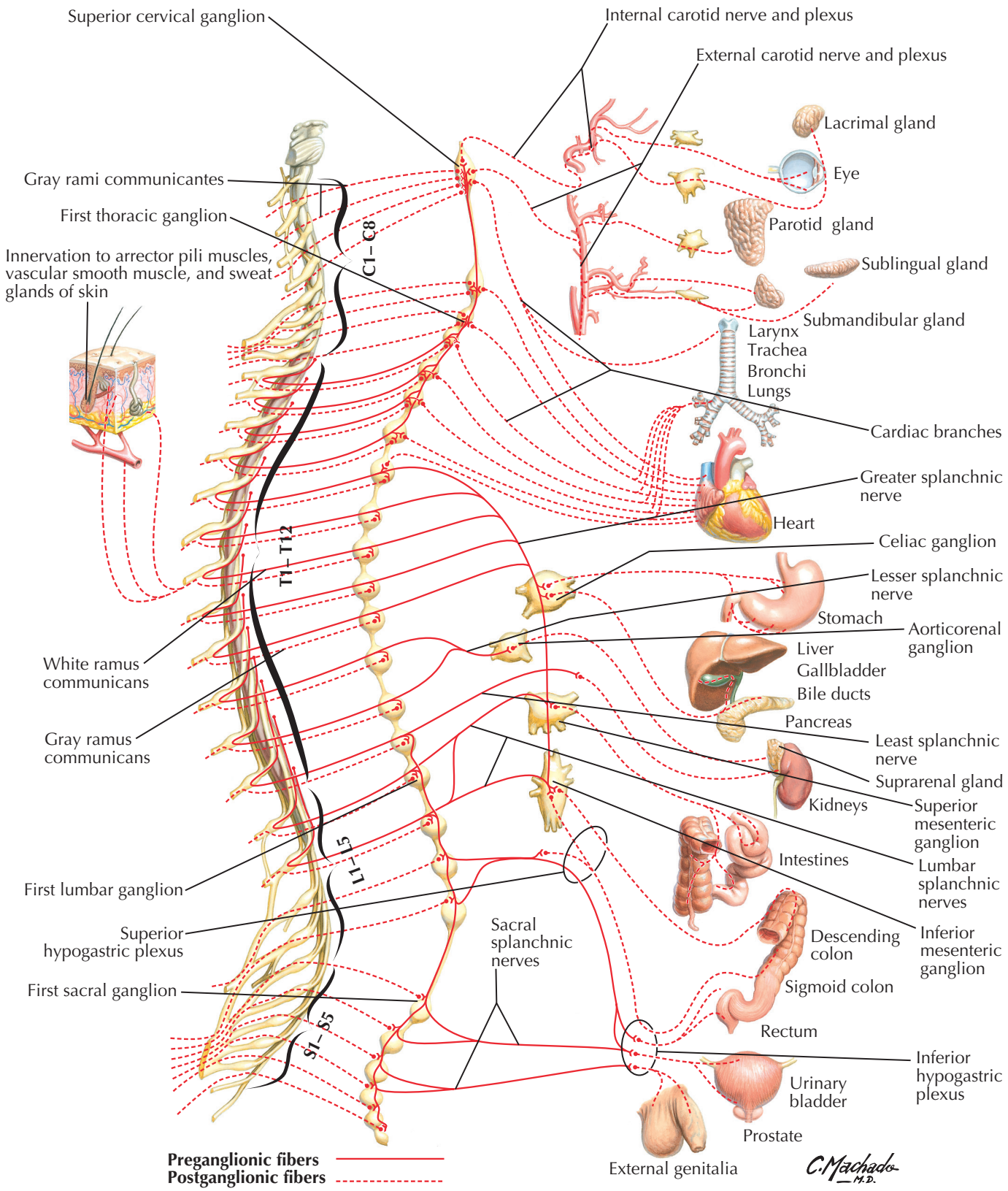


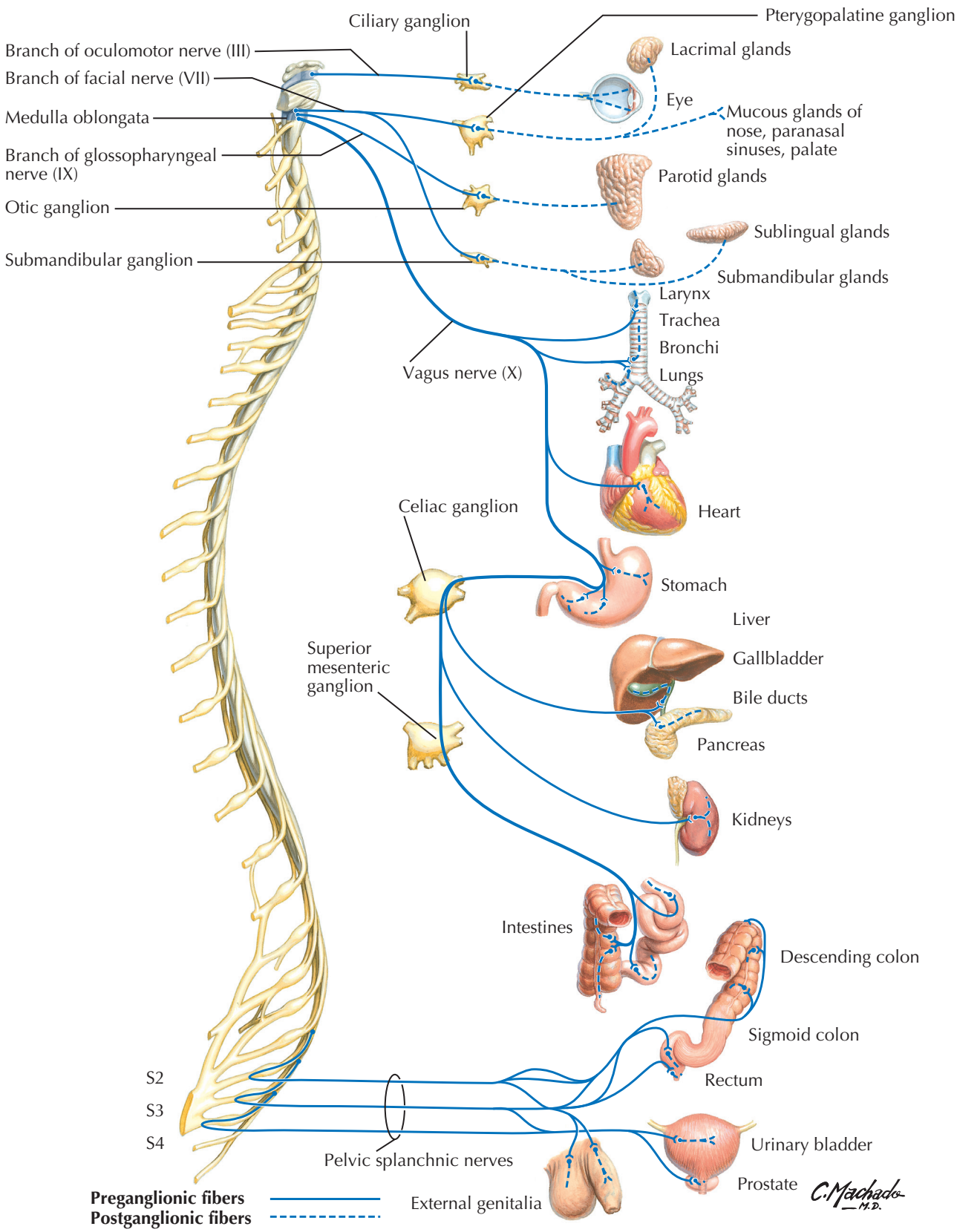
Levels of principal dermatomes

C5	Clavicles
C5, 6	Lateral sides of upper limbs
C8, T1	Medial sides of upper limbs
C6	Digit I (thumb)
C6, 7, 8	Hand
C8	Digits IV and V (ring and little fingers)
T4	Level of nipples
T10	Level of umbilicus
L1	Inguinal region
L1, 2, 3, 4	Anterior and inner surfaces of lower limbs
L4, 5, S1	Foot
L4	Medial side digit I (great toe)
L5, S1, 2	Lateral and posterior surfaces of lower limbs
S1	Lateral margin of foot and digit V (little toe)
S2, 3, 4	Perineum

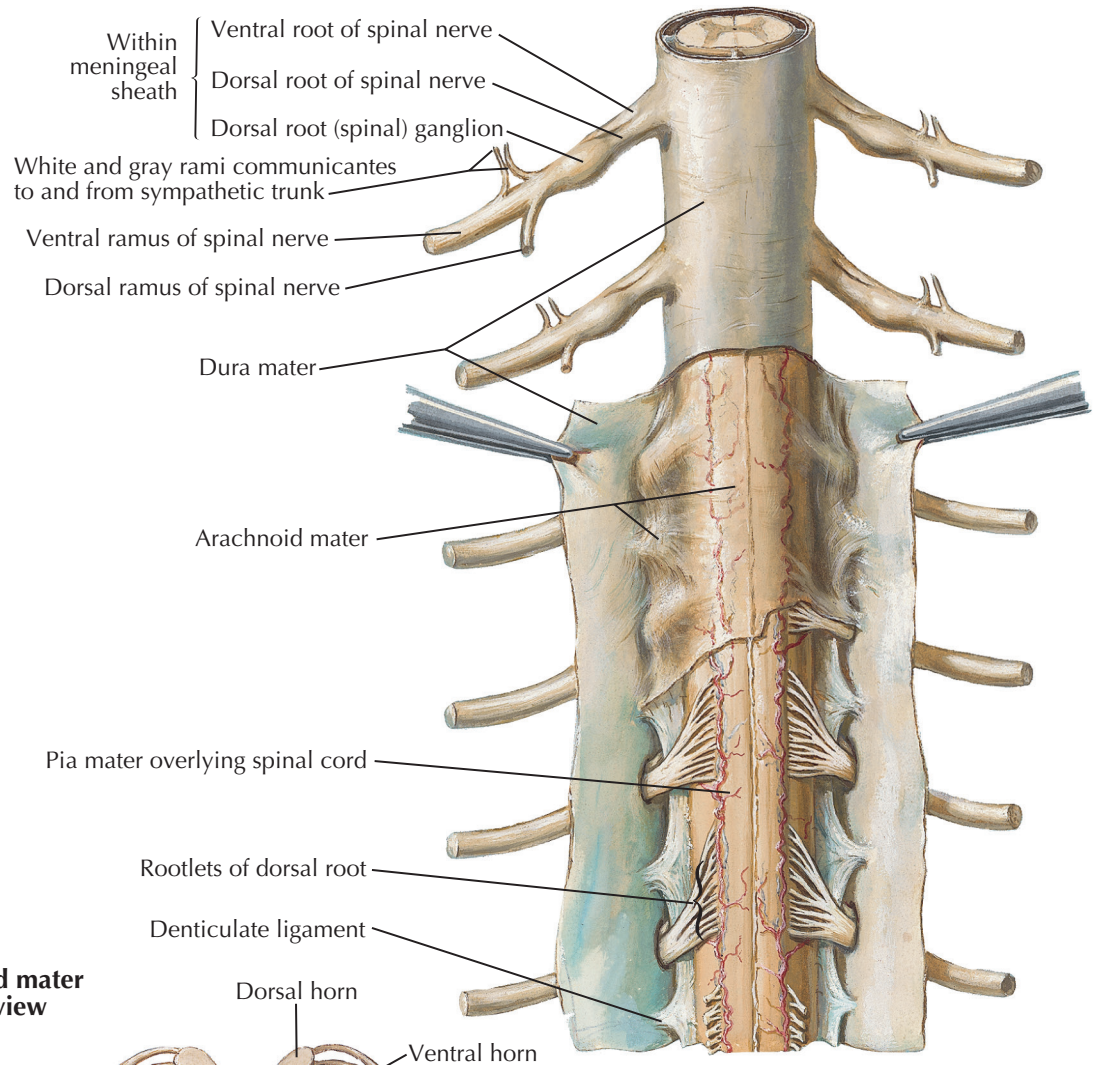
Sympathetic Nervous System: Schema

See also **Plates 206, 317, 319**

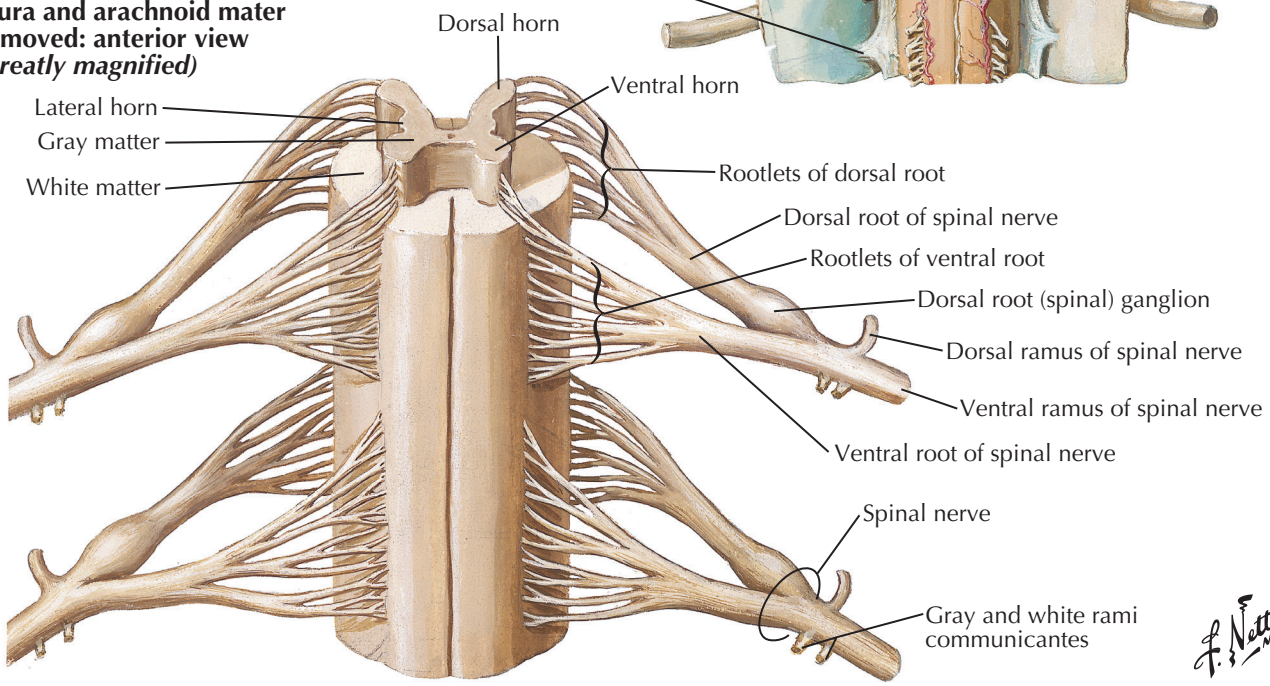



Ciliary ganglion
Pterygopalatine ganglion
Branch of oculomotor nerve (III)
Branch of facial nerve (VII)
Medulla oblongata
Branch of glossopharyngeal nerve (IX)
Otic ganglion
Submandibular ganglion
Lacrimal glands
Eye
Mucous glands of nose, paranasal sinuses, palate
Parotid glands
Sublingual glands
Submandibular glands
Larynx
Trachea
Bronchi
Lungs
Vagus nerve (X)
Heart
Celiac ganglion
Stomach
Liver
Gallbladder
Bile ducts
Pancreas
Superior mesenteric ganglion
Kidneys
Intestines
Descending colon
Sigmoid colon
Rectum
S2
S3
S4
Pelvic splanchnic nerves
Urinary bladder
Prostate
External genitalia
Preganglionic fibers
Postganglionic fibers
C. Machado M.D.

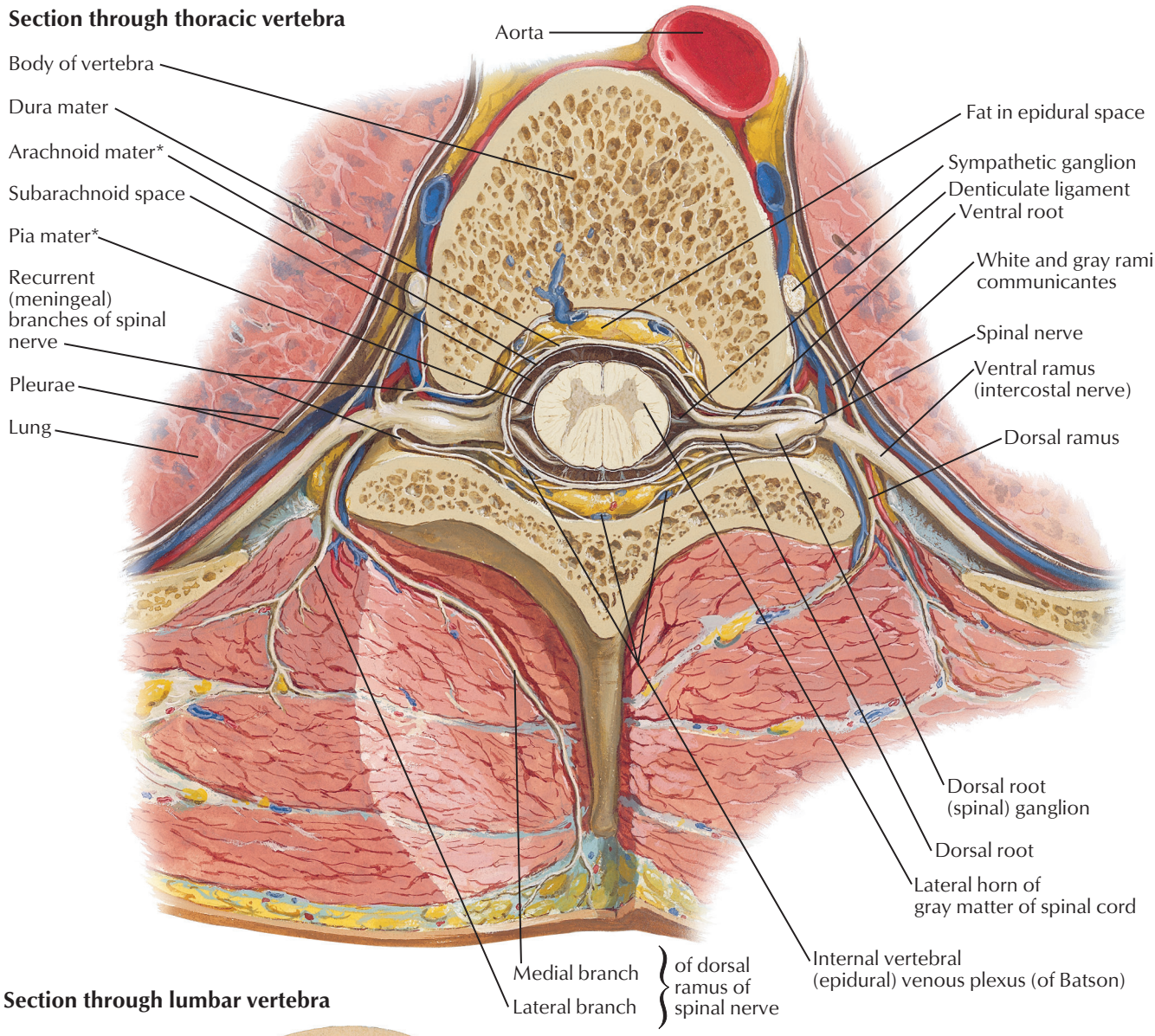
Posterior view



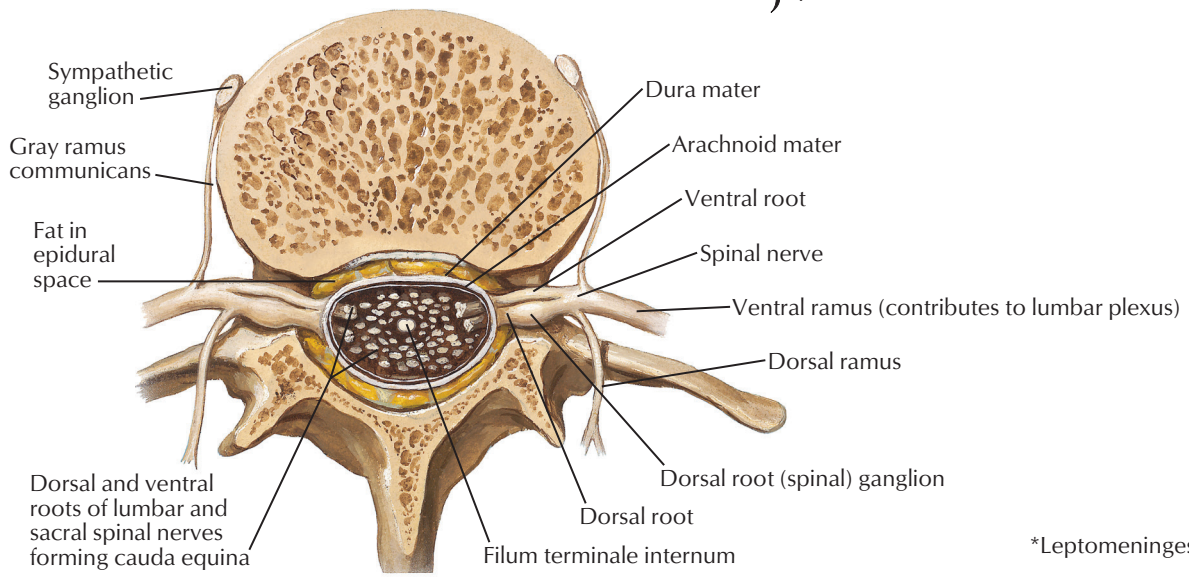
Dura and arachnoid mater removed: anterior view *(greatly magnified)*



Section through thoracic vertebra

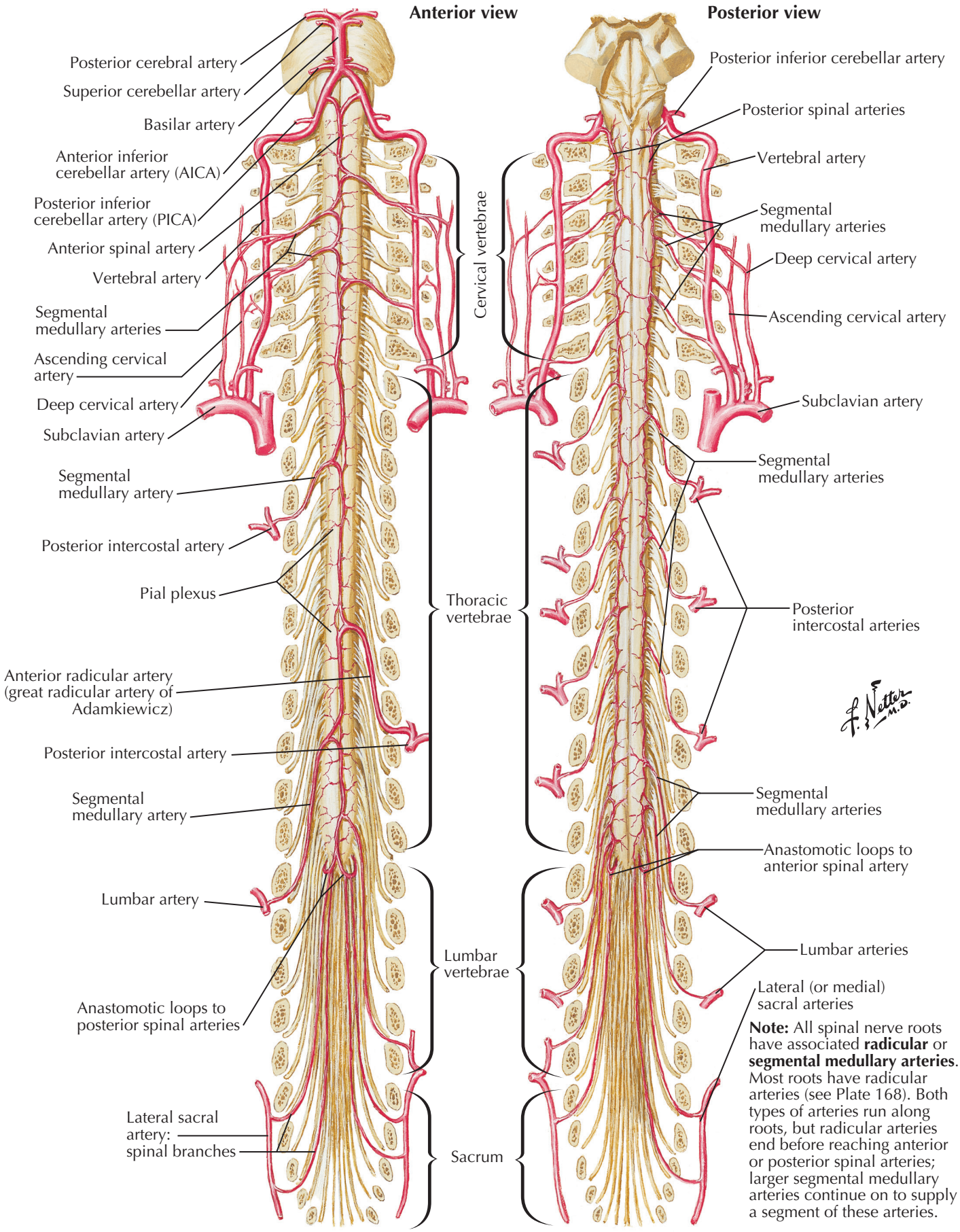


Section through lumbar vertebra



*Leptomeninges

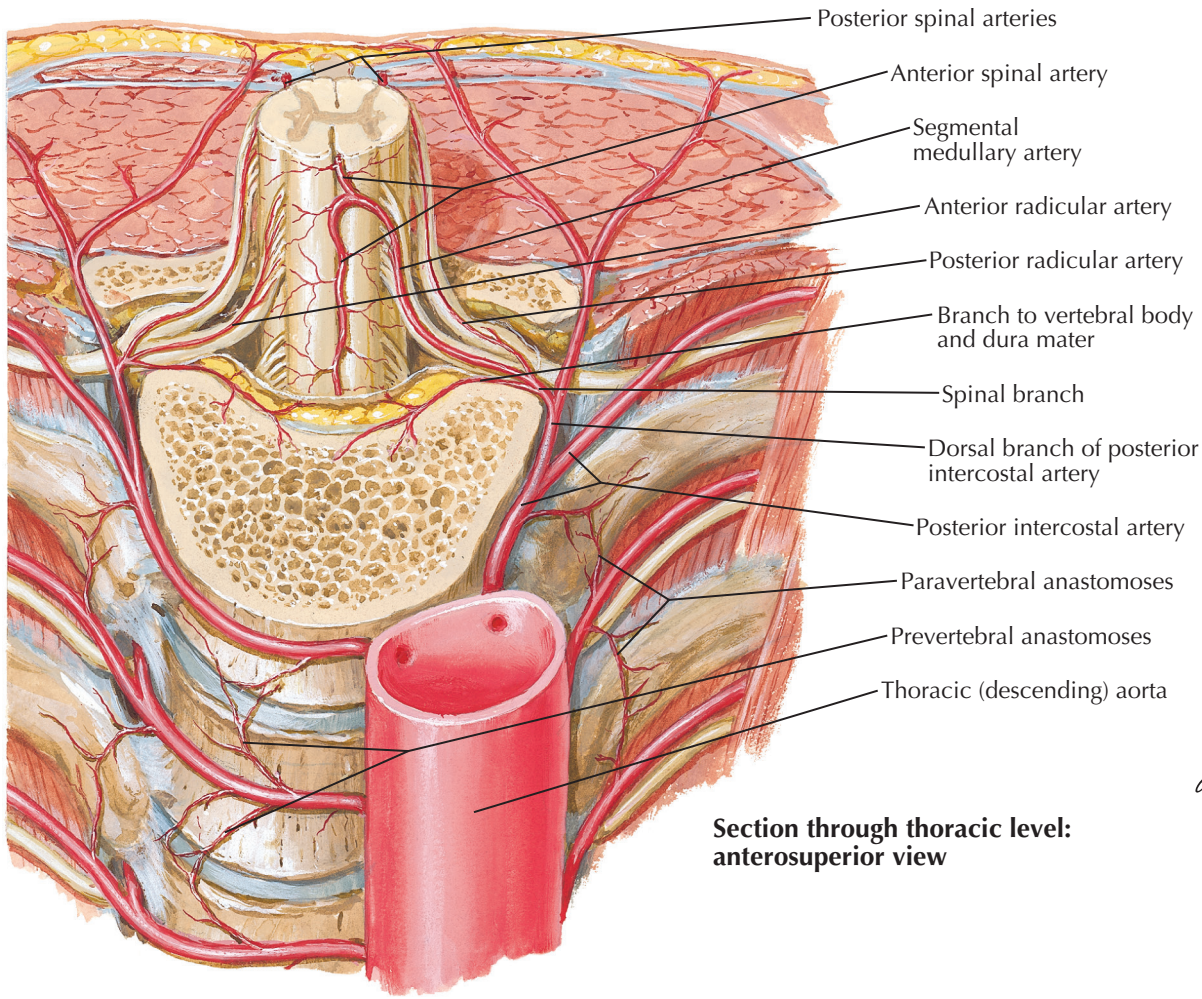
Arteries of Spinal Cord: Schema



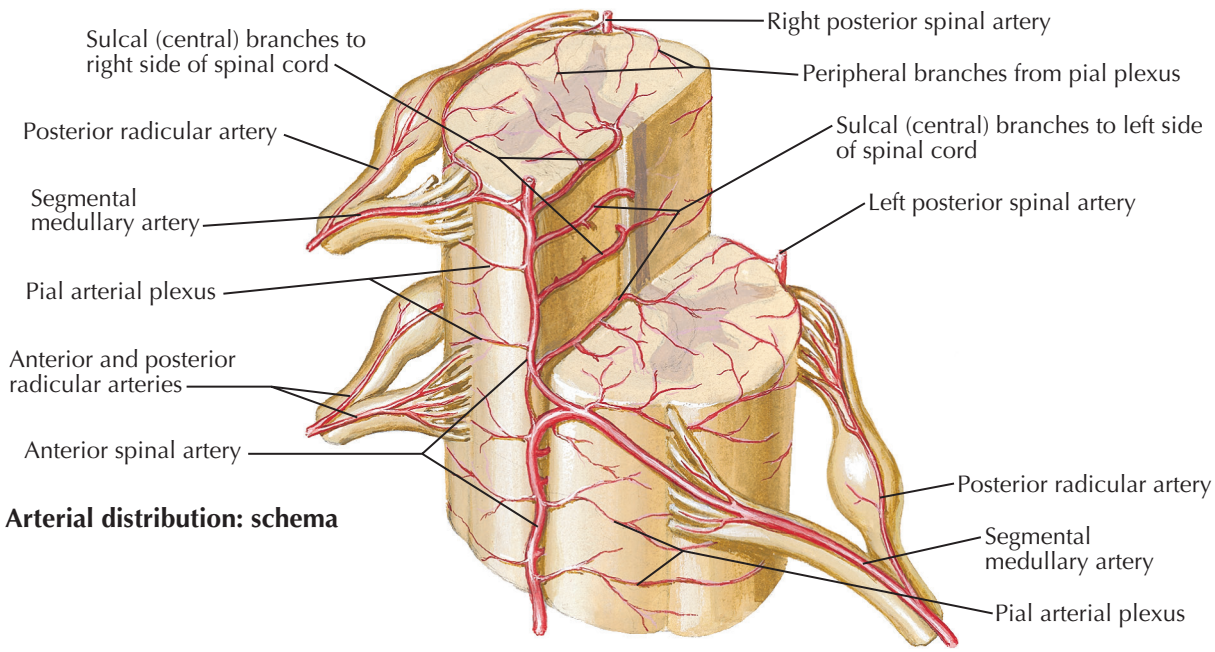
Note: All spinal nerve roots have associated **radicular** or **segmental medullary arteries**. Most roots have radicular arteries (see Plate 168). Both types of arteries run along roots, but radicular arteries end before reaching anterior or posterior spinal arteries; larger segmental medullary arteries continue on to supply a segment of these arteries.

Arteries of Spinal Cord: Intrinsic Distribution

See also **Plate 188**

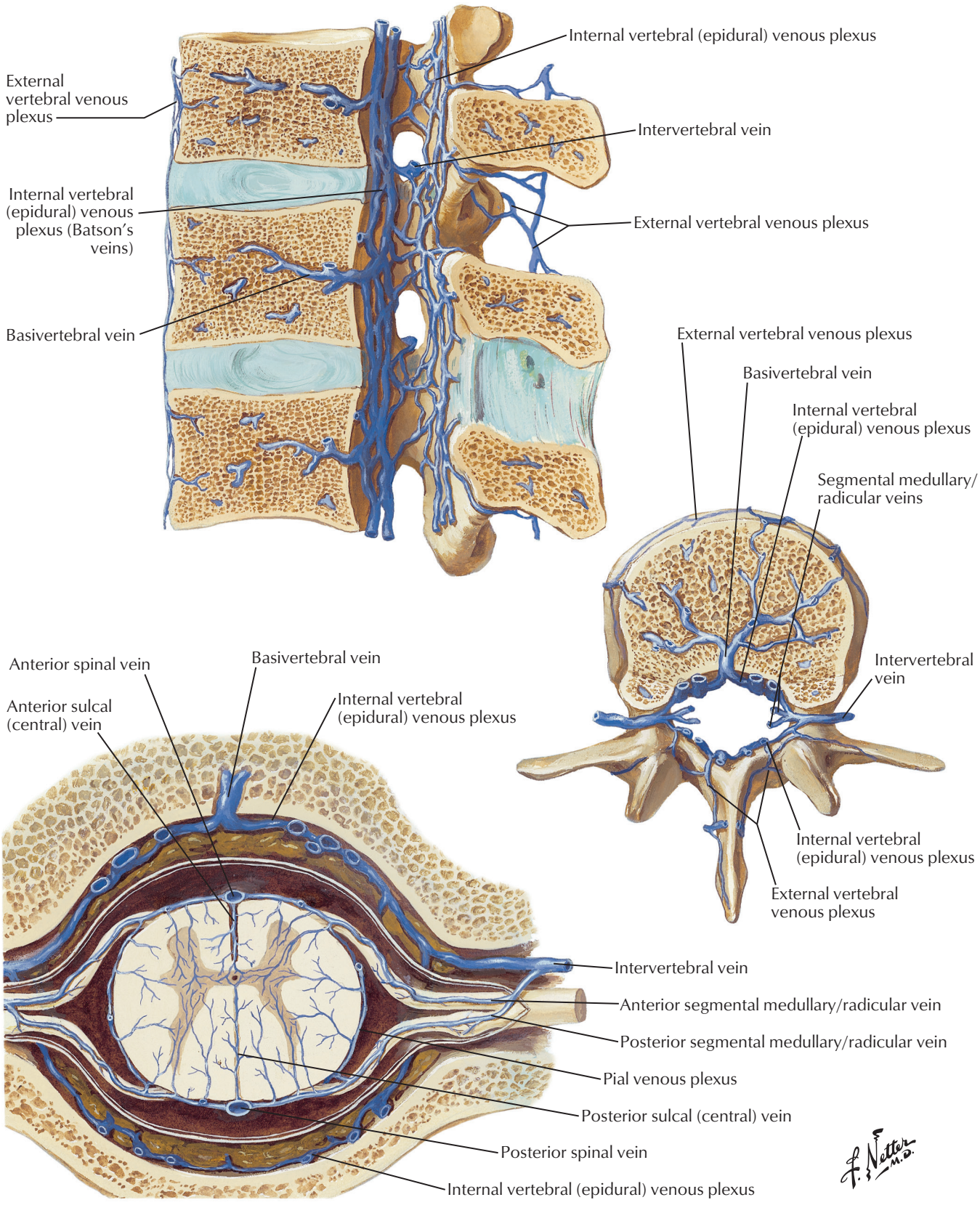


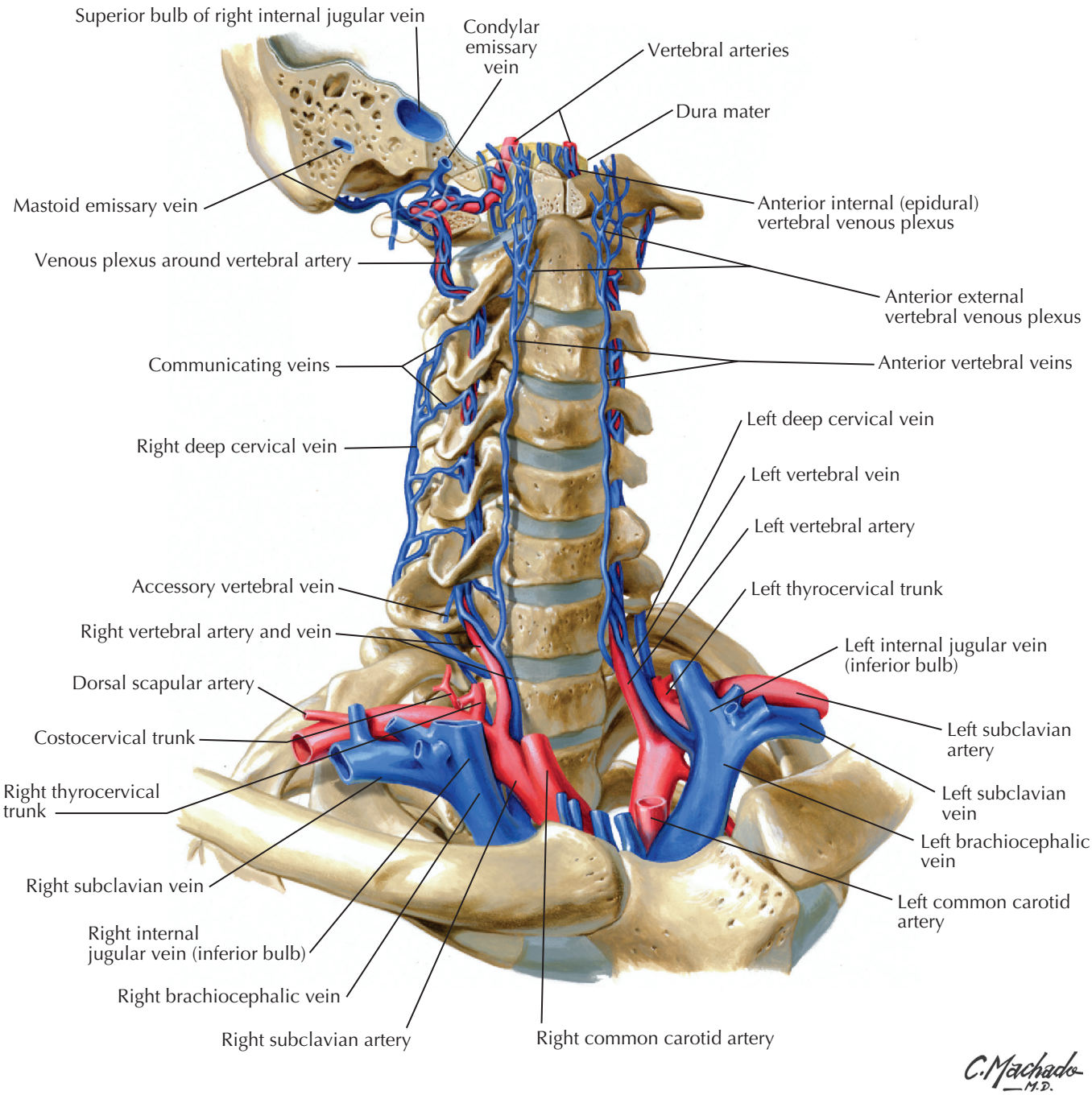
Section through thoracic level: anterosuperior view



Arterial distribution: schema

Veins of Spinal Cord and Vertebral Column




Superior bulb of right internal jugular vein
Condylar emissary vein
Vertebral arteries
Dura mater
Mastoid emissary vein
Anterior internal (epidural) vertebral venous plexus
Venous plexus around vertebral artery
Anterior external vertebral venous plexus
Communicating veins
Anterior vertebral veins
Left deep cervical vein
Right deep cervical vein
Left vertebral vein
Left vertebral artery
Accessory vertebral vein
Left thyrocervical trunk
Right vertebral artery and vein
Left internal jugular vein (inferior bulb)
Dorsal scapular artery
Left subclavian artery
Costocervical trunk
Right thyrocervical trunk
Left subclavian vein
Left brachiocephalic vein
Right subclavian vein
Left common carotid artery
Right internal jugular vein (inferior bulb)
Right brachiocephalic vein
Right subclavian artery
Right common carotid artery
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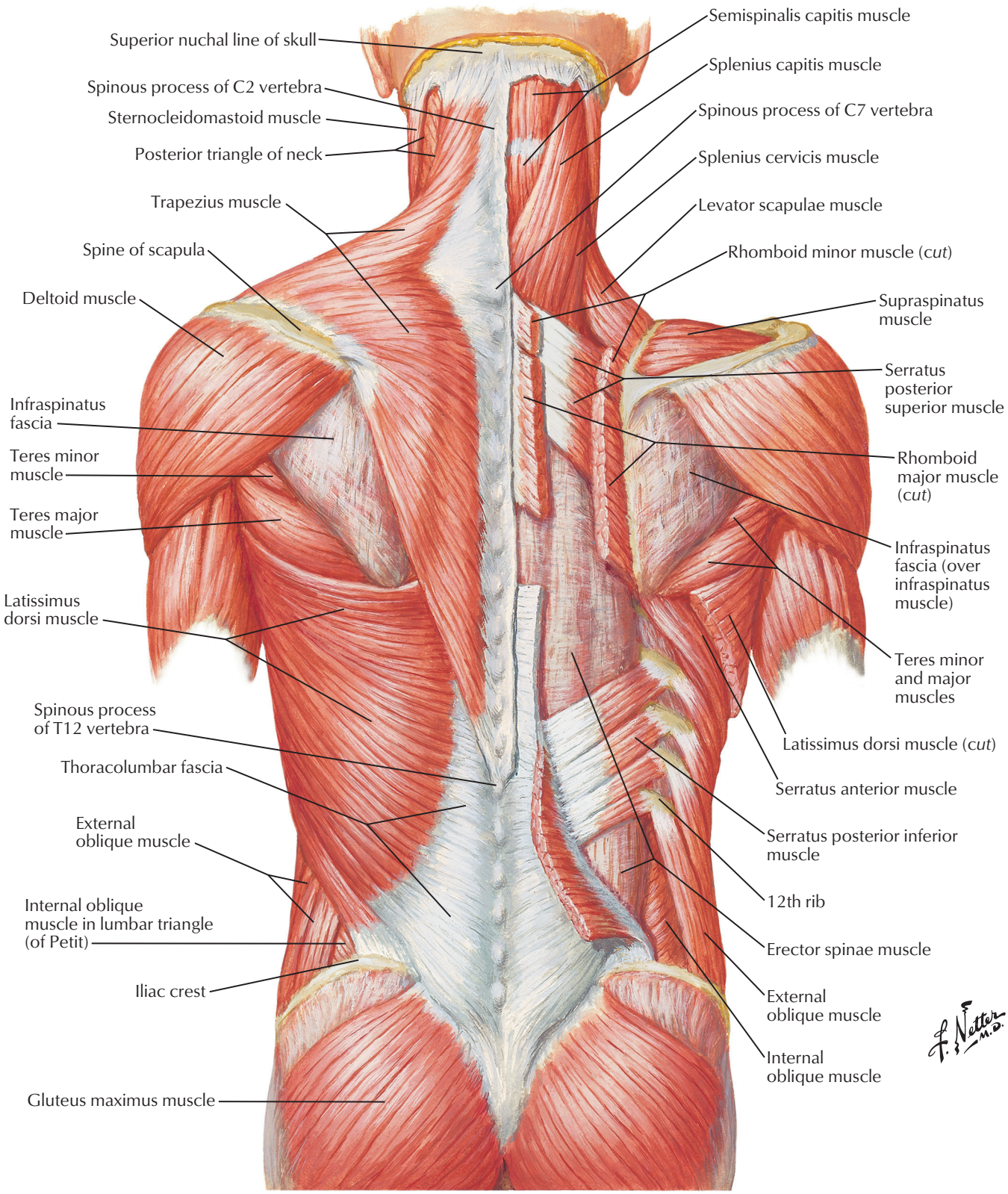
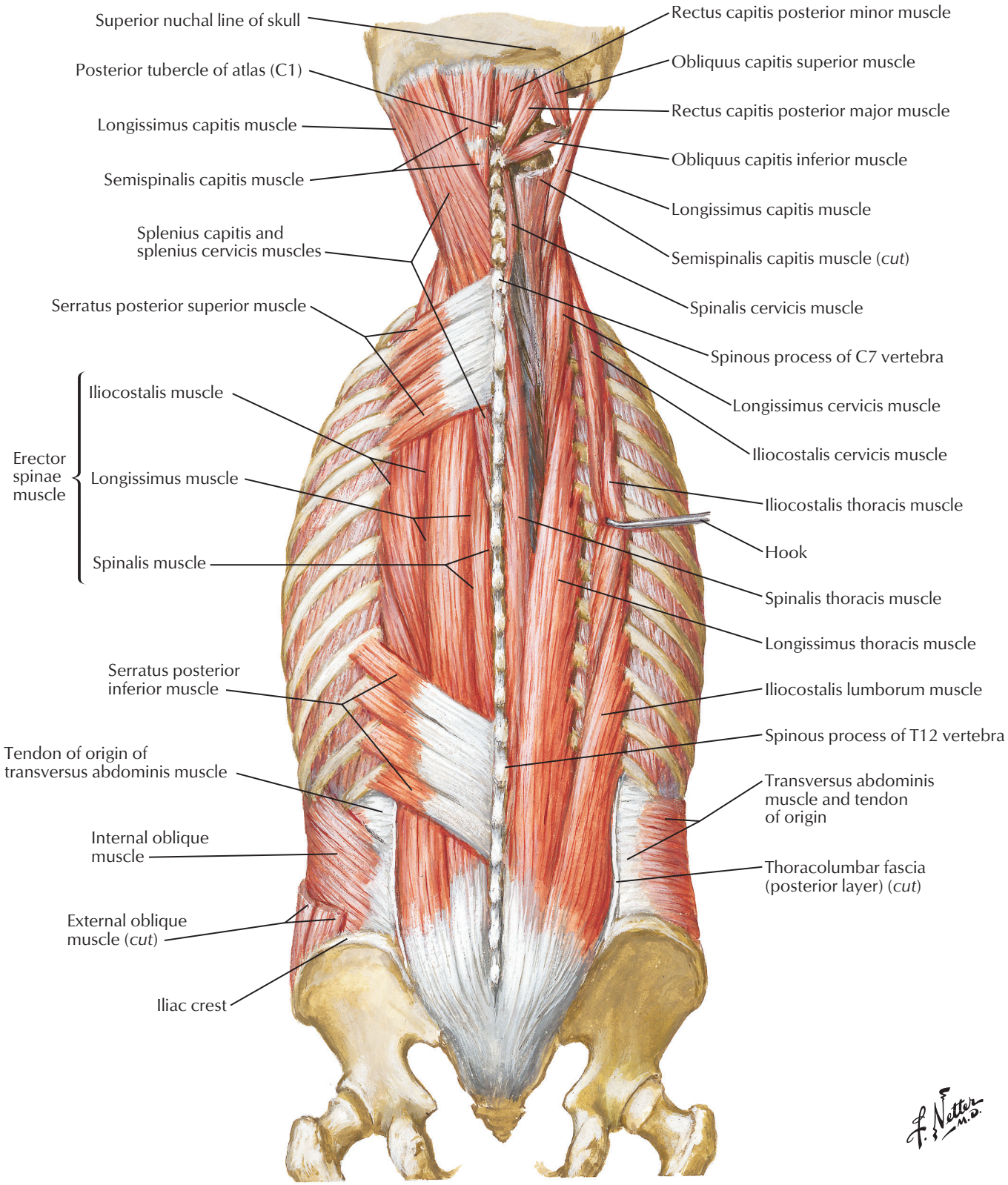
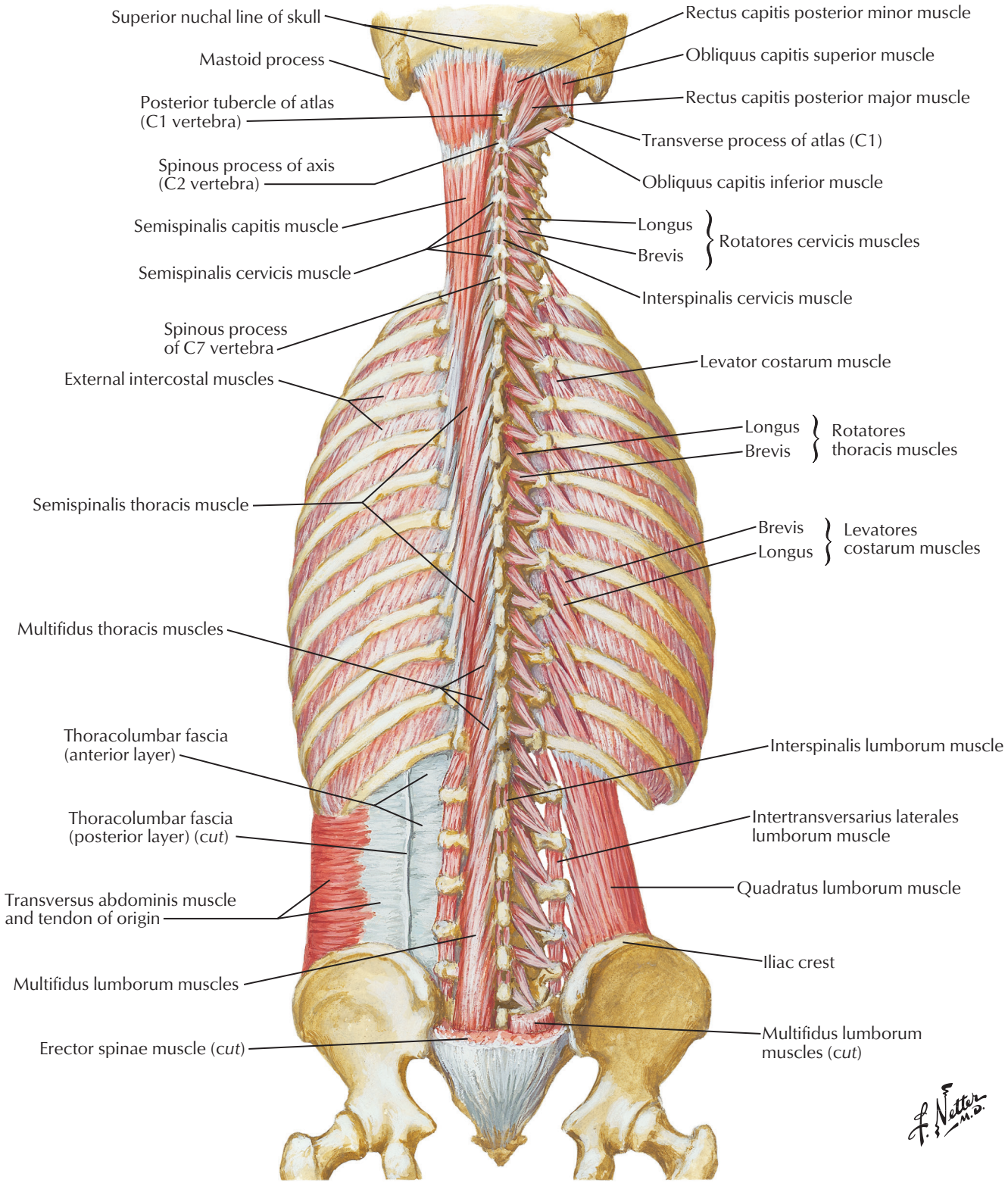
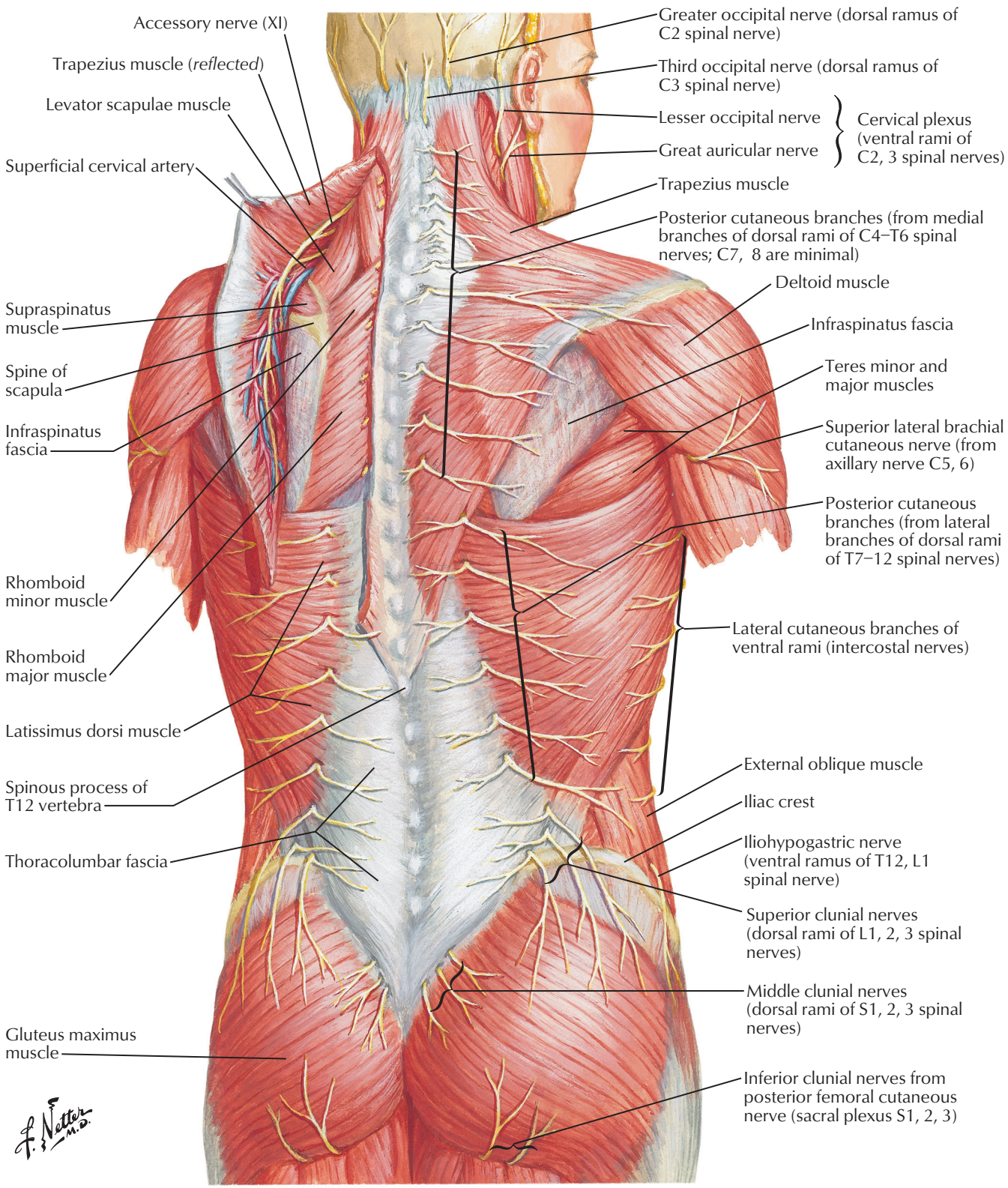
Muscles of Back: Superficial Layers

See also **Plates 29, 250**




Superior nuchal line of skull
Posterior tubercle of atlas (C1)
Longissimus capitis muscle
Semispinalis capitis muscle
Splenius capitis and splenius cervicis muscles
Serratus posterior superior muscle
Erector spinae muscle
Iliocostalis muscle
Longissimus muscle
Spinalis muscle
Serratus posterior inferior muscle
Tendon of origin of transversus abdominis muscle
Internal oblique muscle
External oblique muscle (cut)
Iliac crest
Rectus capitis posterior minor muscle
Obliquus capitis superior muscle
Rectus capitis posterior major muscle
Obliquus capitis inferior muscle
Longissimus capitis muscle
Semispinalis capitis muscle (cut)
Spinalis cervicis muscle
Spinous process of C7 vertebra
Longissimus cervicis muscle
Iliocostalis cervicis muscle
Iliocostalis thoracis muscle
Hook
Spinalis thoracis muscle
Longissimus thoracis muscle
Iliocostalis lumborum muscle
Spinous process of T12 vertebra
Transversus abdominis muscle and tendon of origin
Thoracolumbar fascia (posterior layer) (cut)


Superior nuchal line of skull
Mastoid process
Posterior tubercle of atlas (C1 vertebra)
Spinous process of axis (C2 vertebra)
Semispinalis capitis muscle
Semispinalis cervicis muscle
Spinous process of C7 vertebra
External intercostal muscles
Semispinalis thoracis muscle
Multifidus thoracis muscles
Thoracolumbar fascia (anterior layer)
Thoracolumbar fascia (posterior layer) (cut)
Transversus abdominis muscle and tendon of origin
Multifidus lumborum muscles
Erector spinae muscle (cut)
Rectus capitis posterior minor muscle
Obliquus capitis superior muscle
Rectus capitis posterior major muscle
Transverse process of atlas (C1)
Obliquus capitis inferior muscle
Longus
Brevis
Rotatores cervicis muscles
Interspinalis cervicis muscle
Levator costarum muscle
Longus
Brevis
Rotatores thoracis muscles
Brevis
Longus
Levatores costarum muscles
Interspinalis lumborum muscle
Intertransversarius laterales lumborum muscle
Quadratus lumborum muscle
Iliac crest
Multifidus lumborum muscles (cut)


Accessory nerve (XI)
Trapezius muscle (*reflected*)
Levator scapulae muscle
Superficial cervical artery
Supraspinatus muscle
Spine of scapula
Infraspinatus fascia
Rhomboid minor muscle
Rhomboid major muscle
Latissimus dorsi muscle
Spinous process of T12 vertebra
Thoracolumbar fascia
Gluteus maximus muscle
Greater occipital nerve (dorsal ramus of C2 spinal nerve)
Third occipital nerve (dorsal ramus of C3 spinal nerve)
Lesser occipital nerve
Great auricular nerve
Cervical plexus (ventral rami of C2, 3 spinal nerves)
Trapezius muscle
Posterior cutaneous branches (from medial branches of dorsal rami of C4–T6 spinal nerves; C7, 8 are minimal)
Deltoid muscle
Infraspinatus fascia
Teres minor and major muscles
Superior lateral brachial cutaneous nerve (from axillary nerve C5, 6)
Posterior cutaneous branches (from lateral branches of dorsal rami of T7–12 spinal nerves)
Lateral cutaneous branches of ventral rami (intercostal nerves)
External oblique muscle
Iliac crest
Iliohypogastric nerve (ventral ramus of T12, L1 spinal nerve)
Superior clunial nerves (dorsal rami of L1, 2, 3 spinal nerves)
Middle clunial nerves (dorsal rami of S1, 2, 3 spinal nerves)
Inferior clunial nerves from posterior femoral cutaneous nerve (sacral plexus S1, 2, 3)
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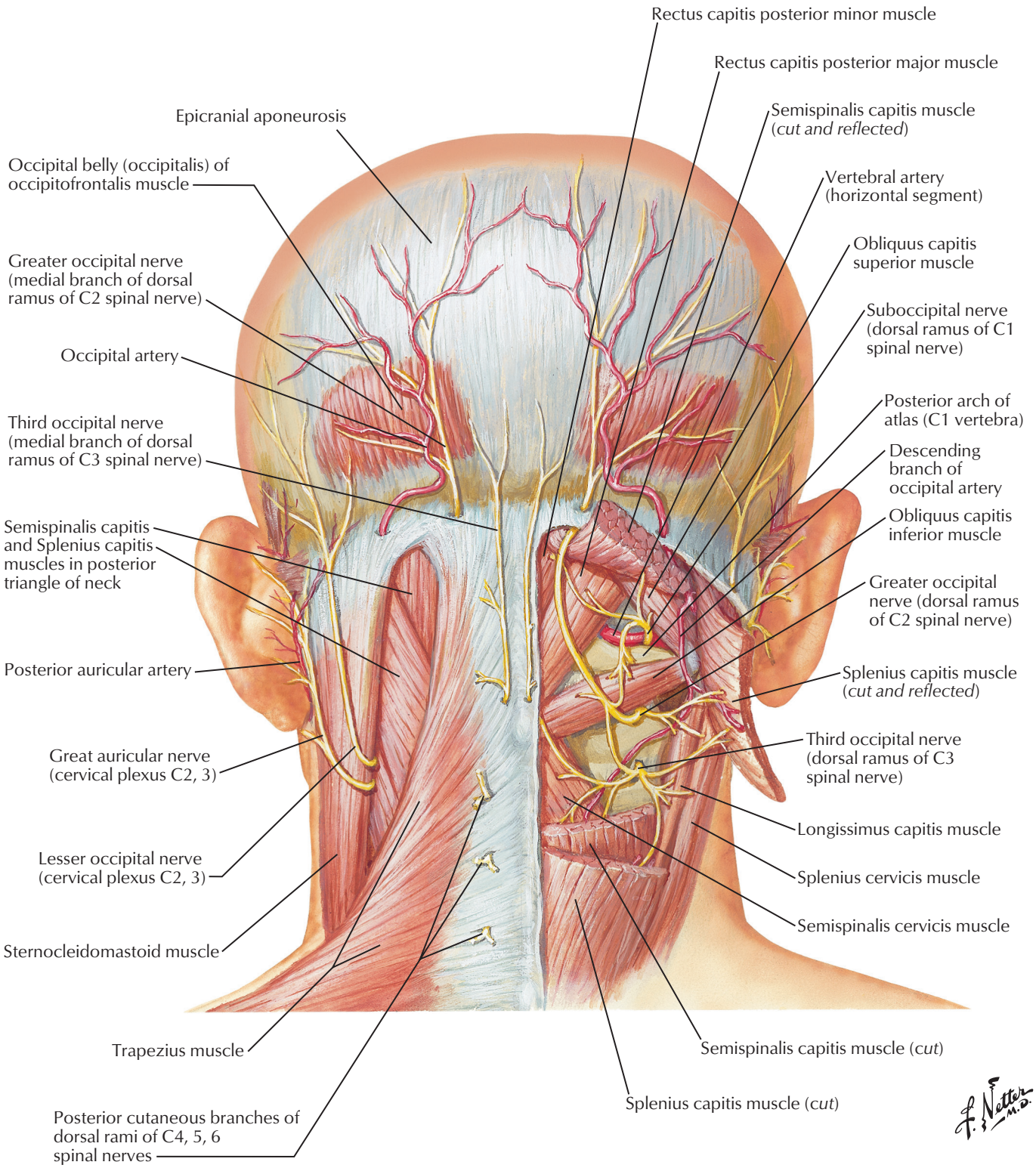
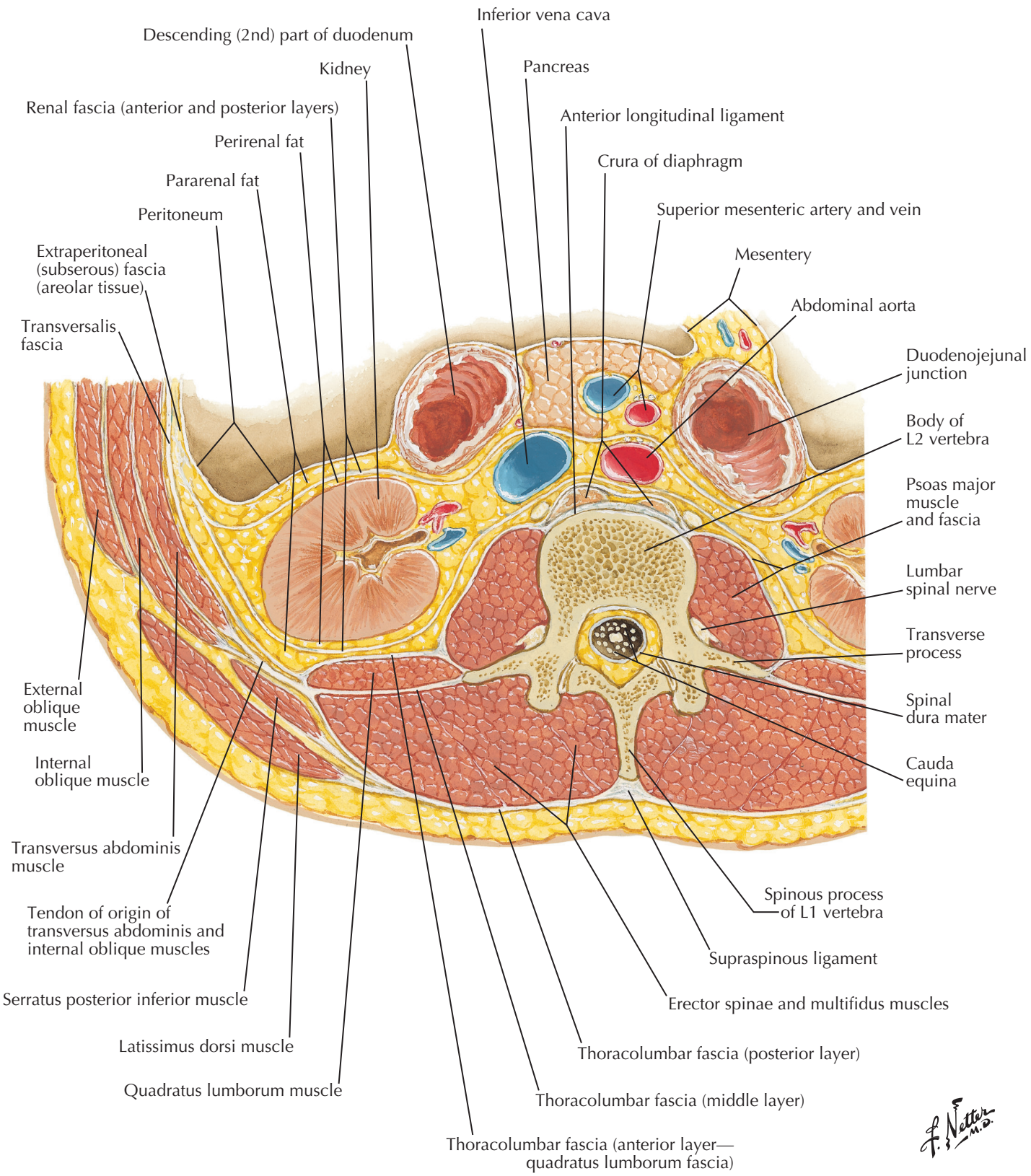
Suboccipital Triangle

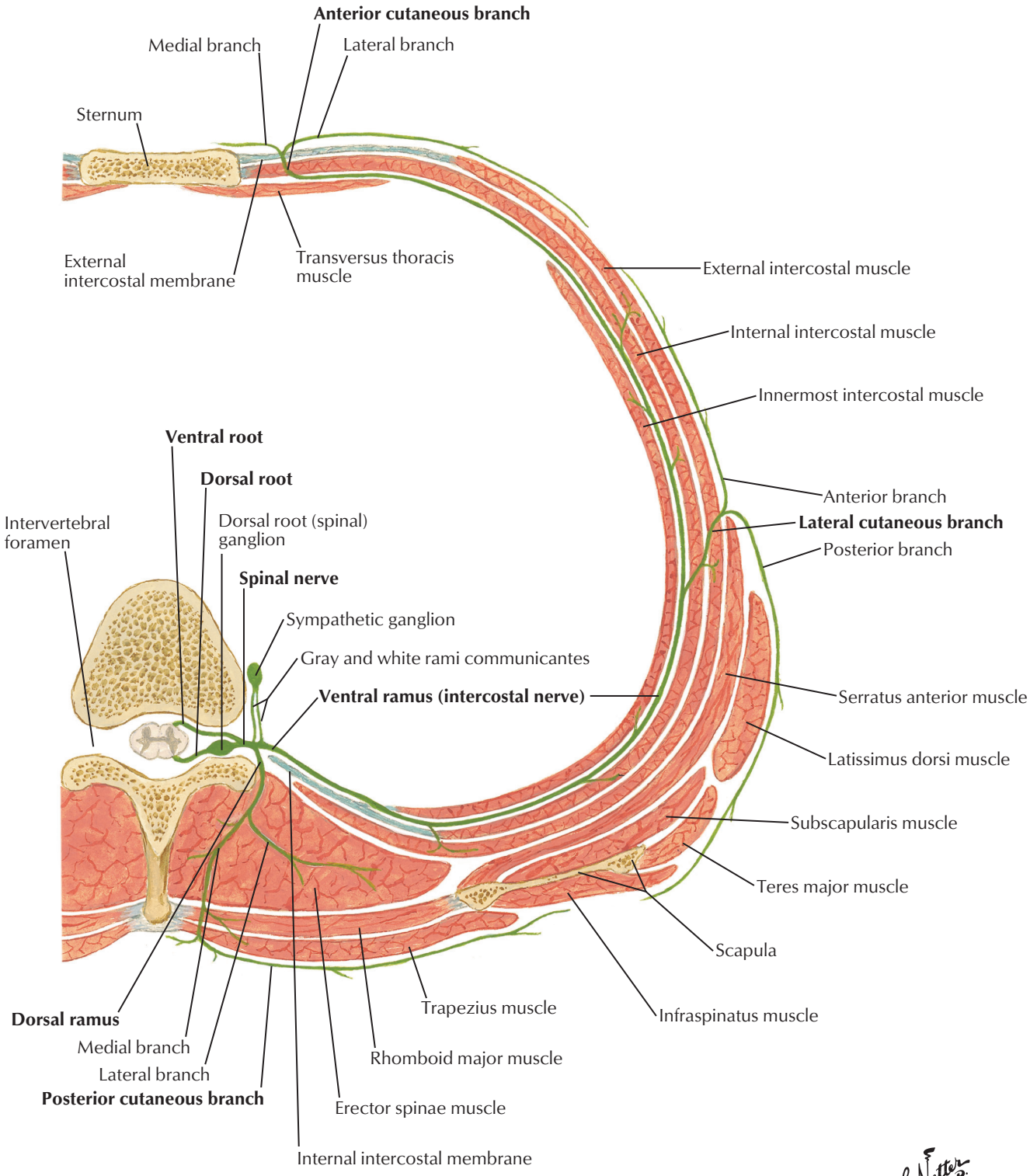
See also **Plates 29, 32**




Inferior vena cava
Descending (2nd) part of duodenum
Kidney
Pancreas
Renal fascia (anterior and posterior layers)
Anterior longitudinal ligament
Perirenal fat
Crura of diaphragm
Pararenal fat
Superior mesenteric artery and vein
Peritoneum
Mesentery
Extraperitoneal (subserous) fascia (areolar tissue)
Abdominal aorta
Transversalis fascia
Duodenojejunal junction
Body of L2 vertebra
Psoas major muscle and fascia
Lumbar spinal nerve
Transverse process
External oblique muscle
Spinal dura mater
Internal oblique muscle
Cauda equina
Transversus abdominis muscle
Spinous process of L1 vertebra
Tendon of origin of transversus abdominis and internal oblique muscles
Supraspinous ligament
Serratus posterior inferior muscle
Erector spinae and multifidus muscles
Latissimus dorsi muscle
Thoracolumbar fascia (posterior layer)
Quadratus lumborum muscle
Thoracolumbar fascia (middle layer)
Thoracolumbar fascia (anterior layer—quadratus lumborum fascia)

Typical Thoracic Spinal Nerve: Cross Section

See also **Plate 254**

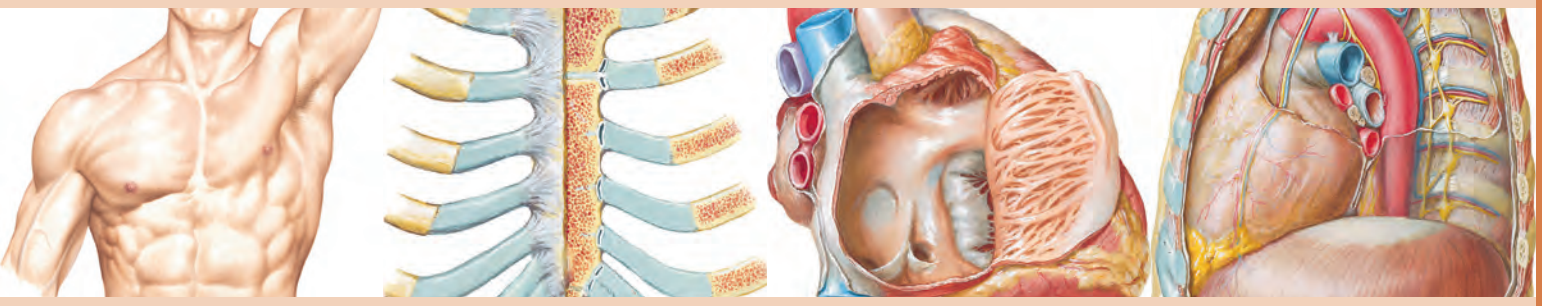


Note: *In lower thoracic region, lateral branch of dorsal ramus is longer, motor, and cutaneous; medial branch is shorter and motor only.*

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Erector spinae	Posterior sacrum, iliac crest, sacrospinous ligament, supraspinous ligament, spinous processes of lower lumbar and sacral vertebrae	*Iliocostalis:* angles of lower ribs, cervical transverse processes *Longissimus:* between tubercles and angles of ribs, transverse processes of thoracic and cervical vertebrae, mastoid process *Spinalis:* spinous processes of upper thoracic and midcervical vertebrae	Dorsal rami of each region	Extends and laterally bends vertebral column and head	*Cervical portions:* occipital, deep cervical, and vertebral arteries *Thoracic portions:* dorsal branches of posterior intercostal, subcostal, and lumbar arteries *Sacral portions:* dorsal branches of lateral sacral arteries	Sacrospinalis
Interspinales (cervical, thoracic, lumbar)	Spinous process	Adjacent spinous process	Dorsal rami of spinal nerves	Aid in extension of vertebral column	*Cervical portions:* occipital, deep cervical, and vertebral arteries *Thoracic portions:* dorsal branches of posterior intercostal arteries *Lumbar portions:* dorsal branches of lumbar arteries	Segmental
Intertransversarii (cervical, thoracic, lumbar)	Extend between adjacent transverse processes of vertebrae	Extend between adjacent transverse processes of vertebrae	Dorsal rami of spinal nerves	Assist in lateral flexion of vertebral column	*Cervical portions:* occipital, deep cervical, and vertebral arteries *Thoracic portions:* dorsal branches of posterior intercostal, subcostal, and lumbar arteries *Lumbar portions:* dorsal branches of lateral lumbar arteries	Segmental
Latissimus dorsi	Spinous processes of T7–L5, thoracolumbar fascia, iliac crest, and last three ribs	Humerus (intertubercular sulcus)	Thoracodorsal nerve	Extends, adducts, and medially rotates humerus	Thoracodorsal artery, dorsal perforating branches of 9th, 10th, and 11th posterior intercostal, subcostal, and first three lumbar arteries	Superficial back
Levator scapulae	Posterior tubercles of transverse processes of C1–C4	Medial border of scapula from superior angle to spine	Ventral rami of C3–C4 and dorsal scapular nerve	Elevates scapula medially, inferiorly rotates glenoid cavity	Dorsal scapular artery, transverse cervical artery, ascending cervical artery	Superficial back
Multifidus	Sacrum, ilium, transverse processes of T1–T12, and articular processes of C4–C7	Spinous processes of vertebrae above, spanning two to four segments	Dorsal rami of each region	Stabilizes spine	*Cervical portions:* occipital, deep cervical, and vertebral arteries *Thoracic portions:* dorsal branches of posterior intercostal, subcostal, and lumbar arteries *Sacral portions:* dorsal branches of lateral sacral arteries	Transversospinalis
Obliquus capitis inferior	Spine of axis	Transverse process of atlas	Suboccipital nerve	Rotates atlas to turn face to same side	Vertebral artery, descending branch of occipital artery	Suboccipital
Obliquus capitis superior	Transverse process of atlas	Occipital bone	Suboccipital nerve	Extends and bends head laterally	Vertebral artery, descending branch of occipital artery	Suboccipital
Rectus capitis posterior major	Spine of axis	Inferior nuchal line	Suboccipital nerve	Extends and rotates head to same side	Vertebral artery, descending branch of occipital artery	Suboccipital

Variations in spinal nerve contributions to the innervation of muscles, their arterial supply, their attachments, and their actions are common themes in human anatomy. Therefore, expect differences between texts and realize that anatomical variation is normal.

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Rectus capitis posterior minor	Tubercle of posterior arch of atlas	Median inferior nuchal line	Suboccipital nerve	Extends head	Vertebral artery, descending branch of occipital artery	Suboccipital
Rhomboid major	Spinous processes of T2–T5 vertebrae	Medial border of scapula below base of spine of scapula	Dorsal scapular nerve	Fixes scapula to thoracic wall and retracts and rotates it to depress glenoid cavity	Dorsal scapular artery *OR* deep branch of transverse cervical artery, dorsal perforating branches of the upper five or six posterior intercostal arteries	Superficial back
Rhomboid minor	Ligamentum nuchae, spines of C7 and T1 vertebrae	Medial border of scapula at spine of scapula	Dorsal scapular nerve	Fixes scapula to thoracic wall and retracts and rotates it to depress glenoid cavity	Dorsal scapular artery *OR* deep branch of transverse cervical artery, dorsal perforating branches of the upper five or six posterior intercostal arteries	Superficial back
Rotatores	Transverse processes of cervical, thoracic, and lumbar regions	Lamina and transverse process of spine above, spanning one or two segments	Dorsal rami of spinal nerves	Stabilizes, extends, and rotates spine	Dorsal branches of segmental arteries	Transversospinalis
Semispinalis	Transverse processes of C4–T12	Spinous processes of cervical and thoracic regions	Dorsal rami of spinal nerves	Extends head, neck, and thorax and rotates them to opposite side	*Cervical portions:* occipital, deep cervical, and vertebral arteries *Thoracic portions:* dorsal branches of posterior intercostal arteries	Transversospinalis
Serratus posterior inferior	Spinous processes of T11–L2	Inferior aspect of ribs 9–12	Ventral rami of lower thoracic nerves	Depresses ribs	Posterior intercostal arteries	Intermediate back
Serratus posterior superior	Ligamentum nuchae, spinous processes of C7–T3	Superior aspect of ribs 2–4	Ventral rami of upper thoracic nerves	Elevates ribs	Posterior intercostal arteries	Intermediate back
Splenius capitis	Nuchal ligament, spinous process of C7–T3	Mastoid process of temporal bone, lateral third of superior nuchal line	Dorsal rami of middle cervical nerves	*Bilaterally:* extend head *Unilaterally*: laterally bends (flexes) and rotates face to same side	Descending branch of occipital artery, deep cervical artery	Spinotransverse
Splenius cervicis	Spinous process of T3–T6	Transverse processes (C1–C3)	Dorsal rami of lower cervical nerves	*Bilaterally*: extend neck *Unilaterally:* laterally bends (flexes) and rotates neck toward same side	Descending branch of occipital artery, deep cervical artery	Spinotransverse
Trapezius	Superior nuchal line, external occipital protuberance, nuchal ligament, spinous processes of C7–T12	Lateral third of clavicle, acromion, spine of scapula	Accessory nerve (CN XI)	Elevates, retracts, and rotates scapula; lower fibers depress scapula	Transverse cervical artery, dorsal perforating branches of posterior intercostal arteries	Superficial back



Section

3 THORAX

Topographic Anatomy
Plate 178

178 Thorax: Surface Anatomy

Mammary Gland
Plates 179–182

179 Mammary Gland

180 Arteries of Mammary Gland

181 Lymph Vessels and Nodes of Mammary Gland

182 Lymphatic Drainage of Breast

Body Wall
Plates 183–192

183 Bony Framework of Thorax

184 Ribs and Associated Joints

185 Anterior Thoracic Wall

186 Anterior Thoracic Wall (continued)

187 Anterior Thoracic Wall: Internal View

188 Intercostal Nerves and Arteries

189 Veins of Internal Thoracic Wall

190 Phrenic Nerve

191 Diaphragm: Thoracic Surface

192 Diaphragm: Abdominal Surface

Lungs
Plates 193–207

193 Topography of Lungs: Anterior View

194 Topography of Lungs: Posterior View

195 Lungs in Situ: Anterior View
196 Lungs: Medial Views
197 Bronchopulmonary Segments
198 Bronchopulmonary Segments (continued)
199 Trachea and Major Bronchi
200 Nomenclature of Bronchi: Schema
201 Intrapulmonary Airways: Schema
202 Intrapulmonary Blood Circulation: Schema
203 Great Vessels of Superior Mediastinum
204 Bronchial Arteries and Veins
205 Lymph Vessels and Nodes of Lung
206 Autonomic Nerves in Thorax
207 Innervation of Tracheobronchial Tree: Schema

Heart

Plates 208–226

208 Heart in Situ
209 Heart: Anterior Exposure
210 Radiology and Auscultation of Heart
211 Heart: Base and Diaphragmatic Surface
212 Pericardial Sac
213 Mediastinum: Cross Section
214 Thorax: Coronal Section of Heart, Ascending Aorta
215 Coronary Arteries and Cardiac Veins
216 Coronary Arteries: Imaging
217 Right Atrium and Ventricle
218 Left Atrium and Ventricle
219 Valves and Fibrous Skeleton of Heart
220 Valves and Fibrous Skeleton of Heart (continued)
221 Atria, Ventricles, and Interventricular Septum
222 Conducting System of Heart
223 Nerves of Heart
224 Innervation of Heart: Schema
225 Innervation of Blood Vessels: Schema
226 Prenatal and Postnatal Circulation

Mediastinum

Plates 227–236

227 Mediastinum: Right Lateral View
228 Mediastinum: Left Lateral View
229 Esophagus in Situ
230 Topography and Constrictions of Esophagus
231 Musculature of Esophagus
232 Esophagogastric Junction
233 Arteries of Esophagus
234 Veins of Esophagus
235 Lymph Vessels and Nodes of Esophagus
236 Nerves of Esophagus

Regional Scans

Plate 237

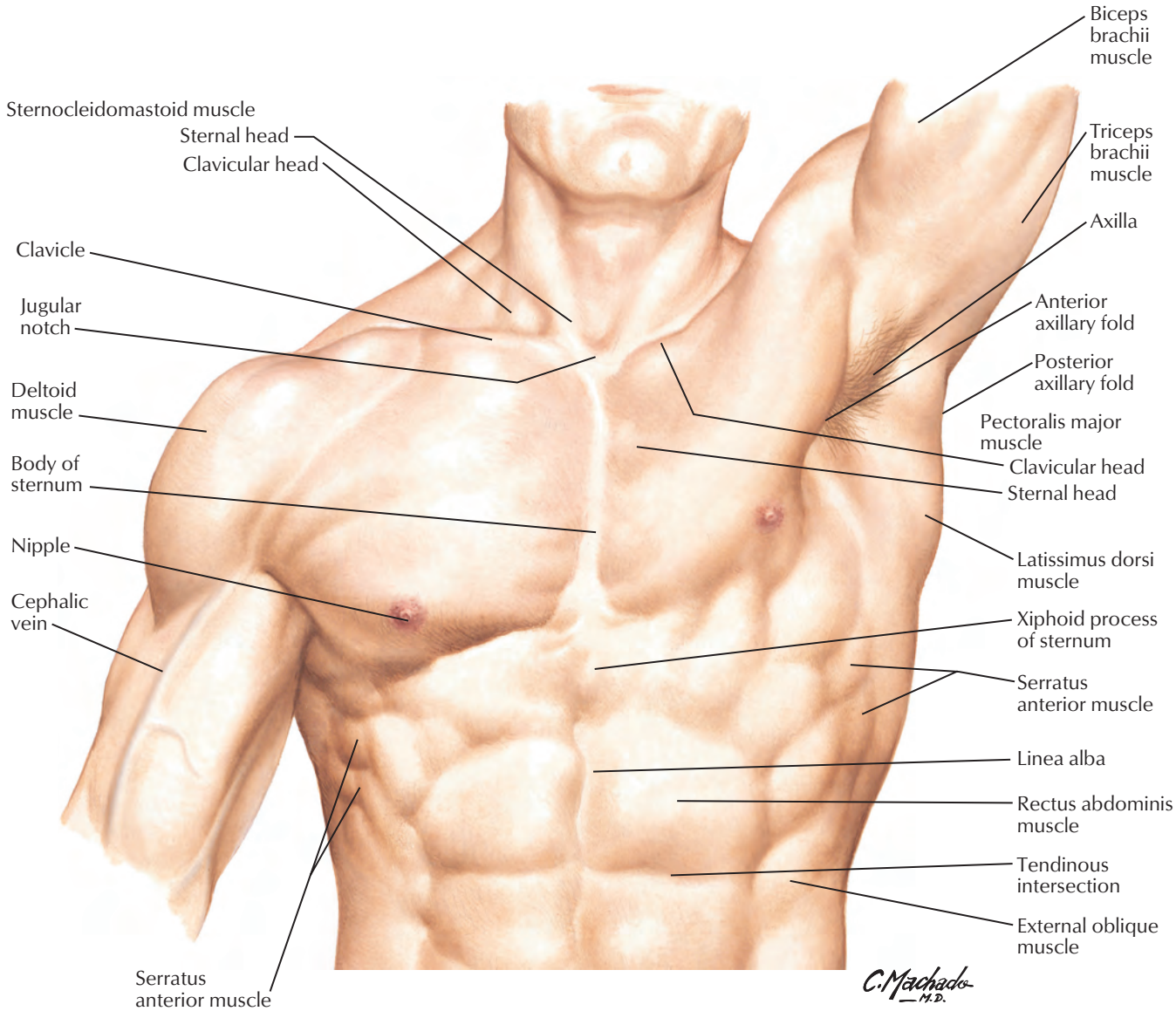
237 Chest Scans: Axial CT Images

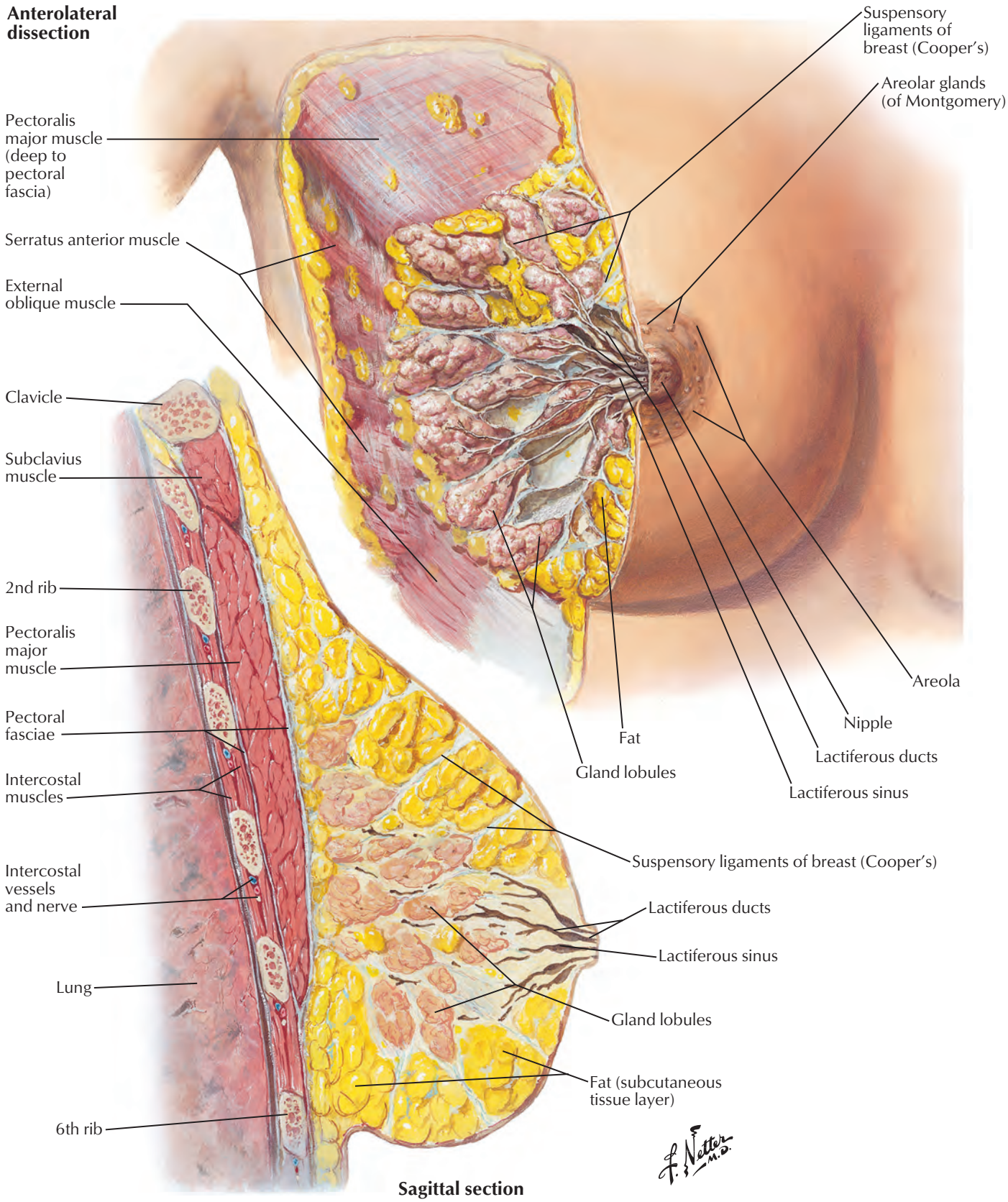
Cross-Sectional Anatomy

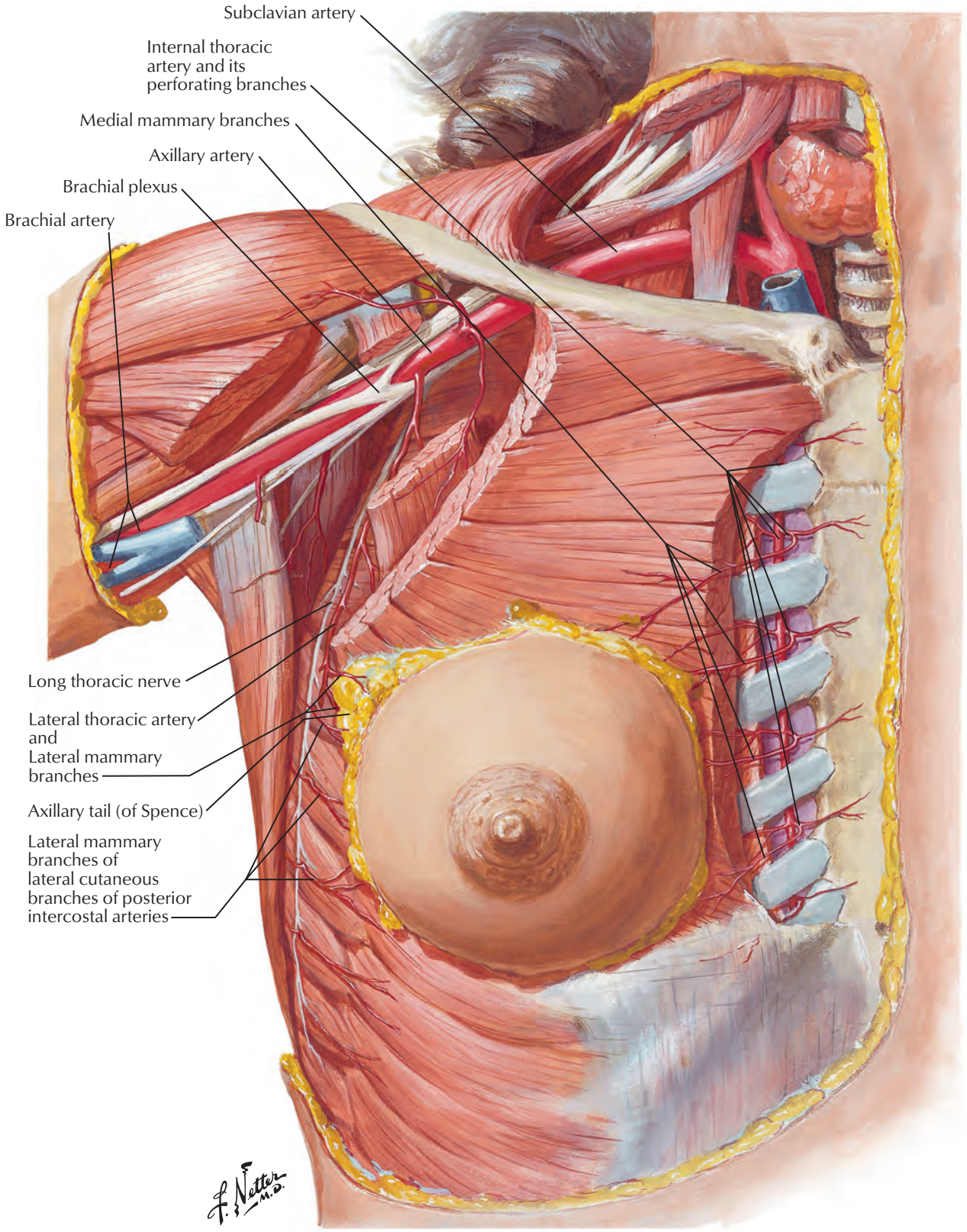
Plates 238–241

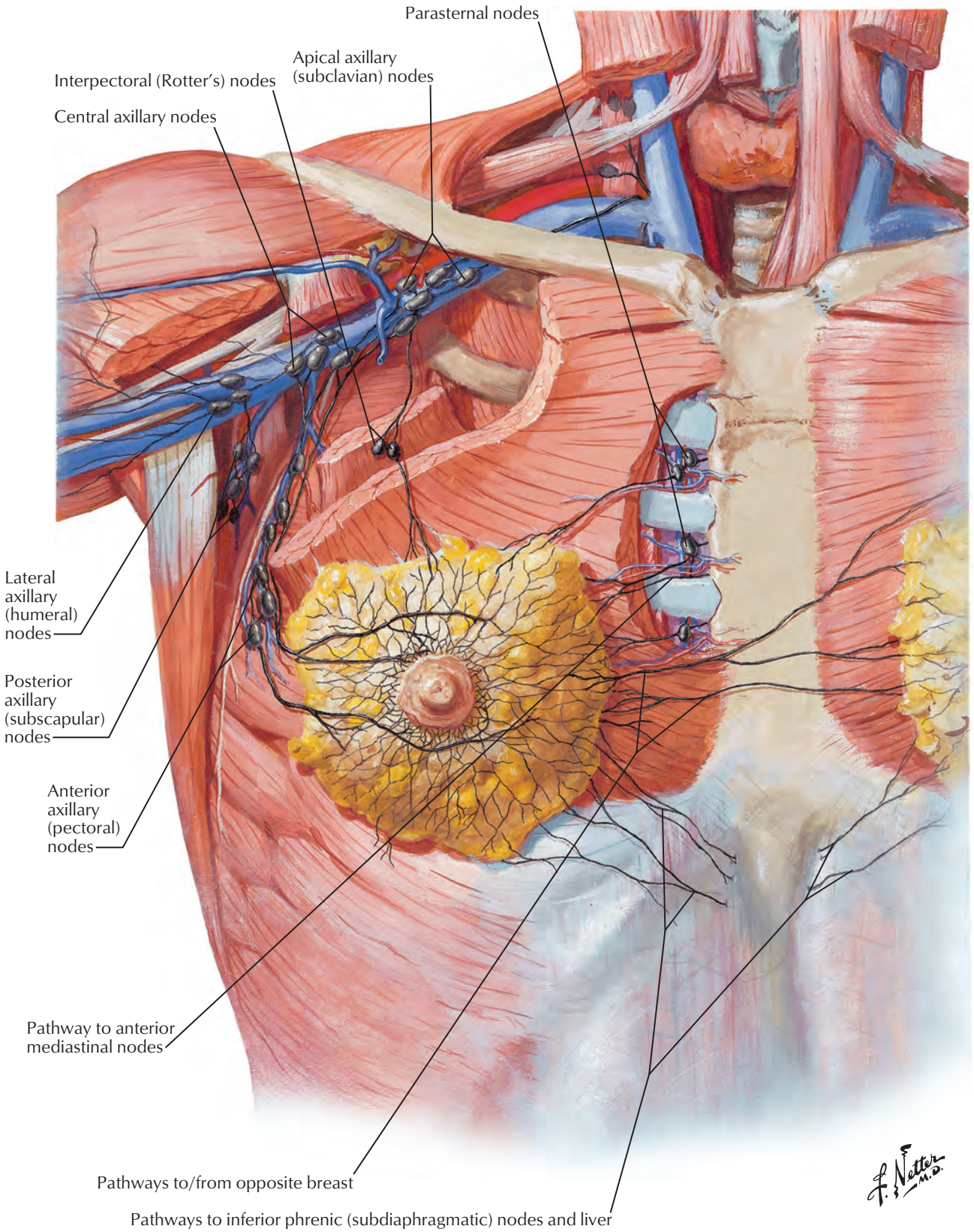
238 Cross Section of Thorax at T3 Level
239 Cross Section of Thorax at T3-4 Disc Level
240 Cross Section of Thorax at T4-5 Disc Level
241 Cross Section of Thorax at T7 Level

Muscle Table


Biceps brachii muscle
Sternocleidomastoid muscle
Sternal head
Clavicular head
Triceps brachii muscle
Axilla
Clavicle
Jugular notch
Anterior axillary fold
Posterior axillary fold
Deltoid muscle
Pectoralis major muscle
Clavicular head
Body of sternum
Sternal head
Nipple
Latissimus dorsi muscle
Cephalic vein
Xiphoid process of sternum
Serratus anterior muscle
Linea alba
Rectus abdominis muscle
Tendinous intersection
External oblique muscle
Serratus anterior muscle
C. Machado M.D.

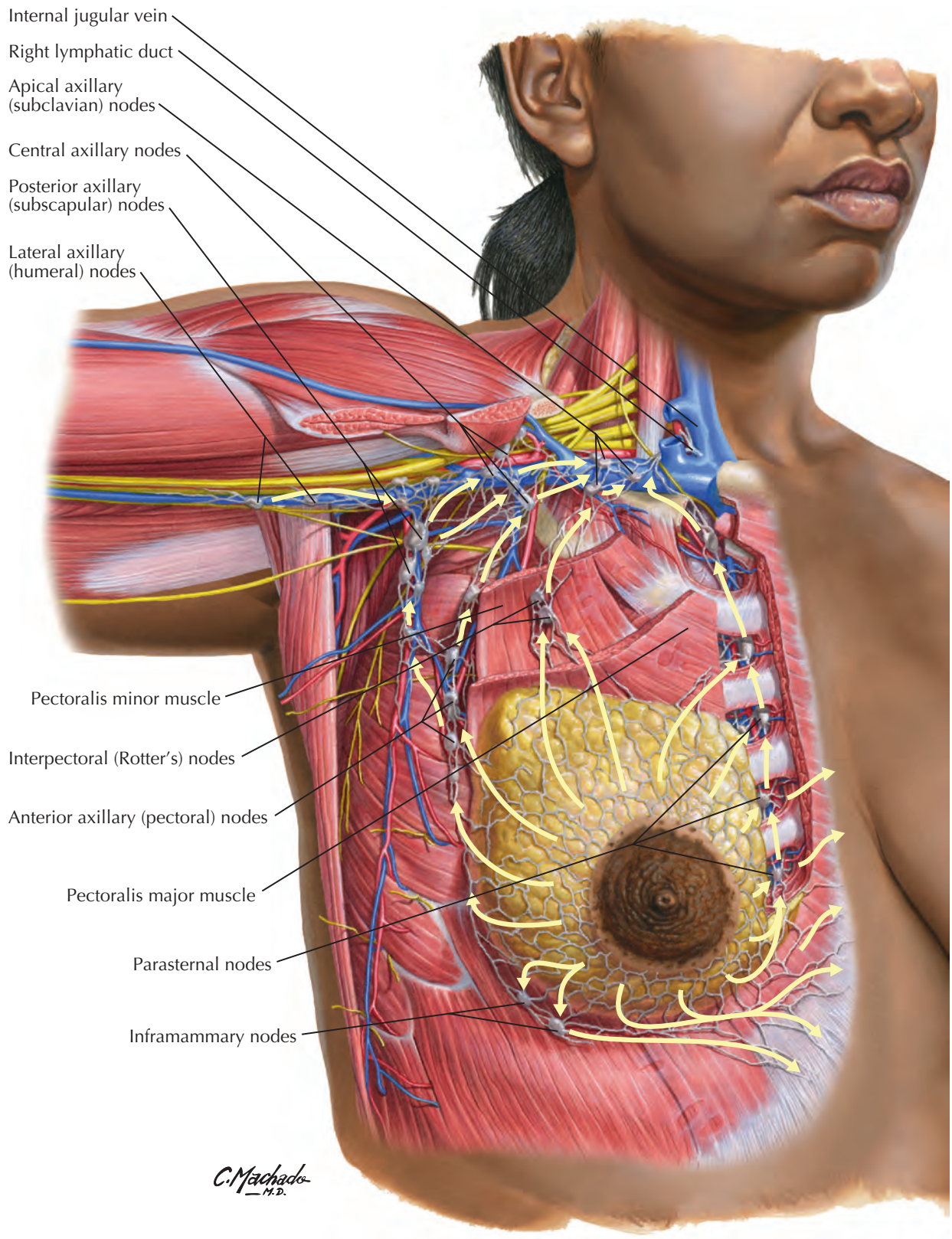

Anterolateral dissection
Suspensory ligaments of breast (Cooper's)
Areolar glands (of Montgomery)
Pectoralis major muscle (deep to pectoral fascia)
Serratus anterior muscle
External oblique muscle
Clavicle
Subclavius muscle
2nd rib
Pectoralis major muscle
Pectoral fasciae
Intercostal muscles
Intercostal vessels and nerve
Lung
6th rib
Areola
Nipple
Fat
Lactiferous ducts
Gland lobules
Lactiferous sinus
Suspensory ligaments of breast (Cooper's)
Lactiferous ducts
Lactiferous sinus
Gland lobules
Fat (subcutaneous tissue layer)
Sagittal section

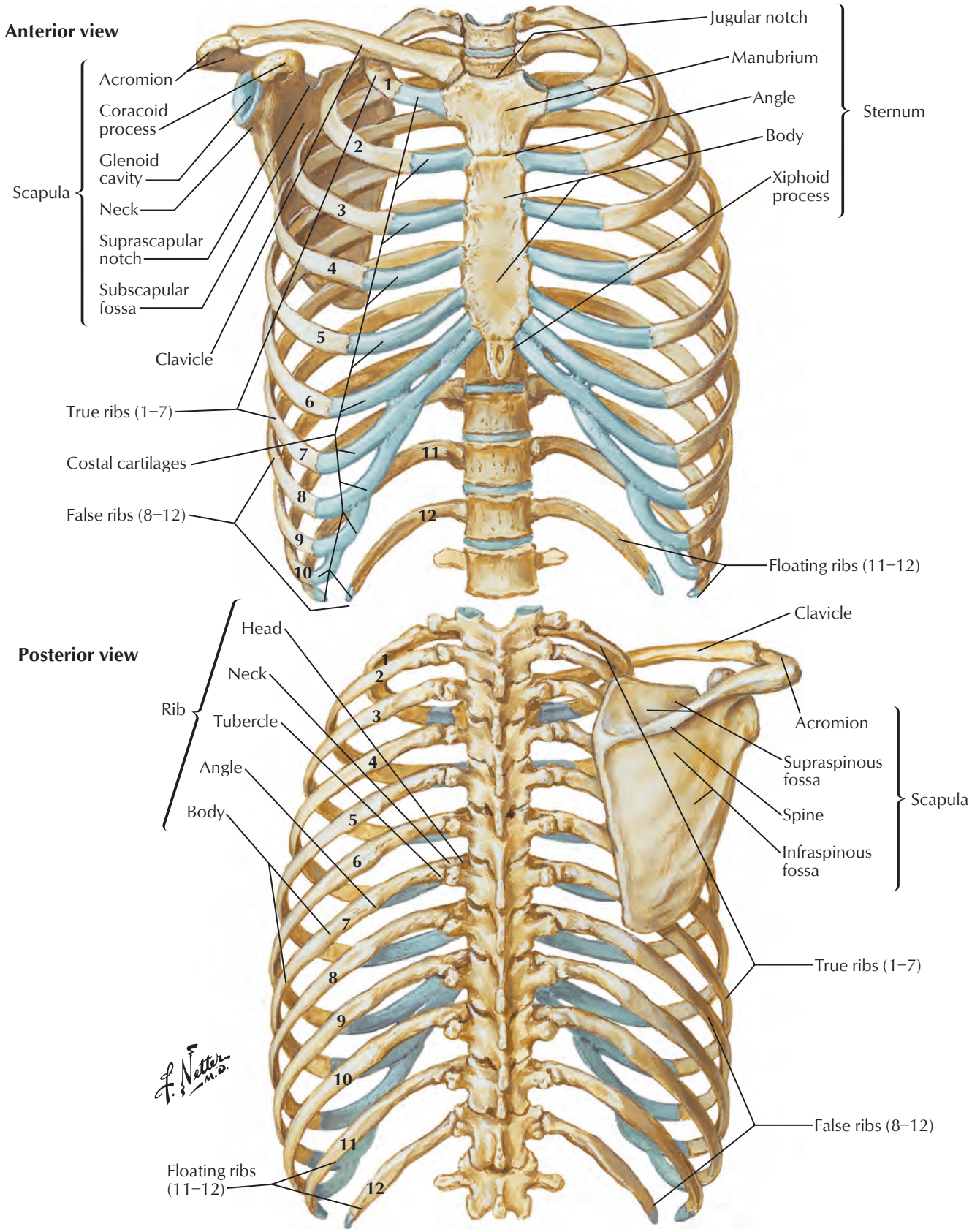

Subclavian artery
Internal thoracic artery and its perforating branches
Medial mammary branches
Axillary artery
Brachial plexus
Brachial artery
Long thoracic nerve
Lateral thoracic artery and Lateral mammary branches
Axillary tail (of Spence)
Lateral mammary branches of lateral cutaneous branches of posterior intercostal arteries
F. Netter M.D.

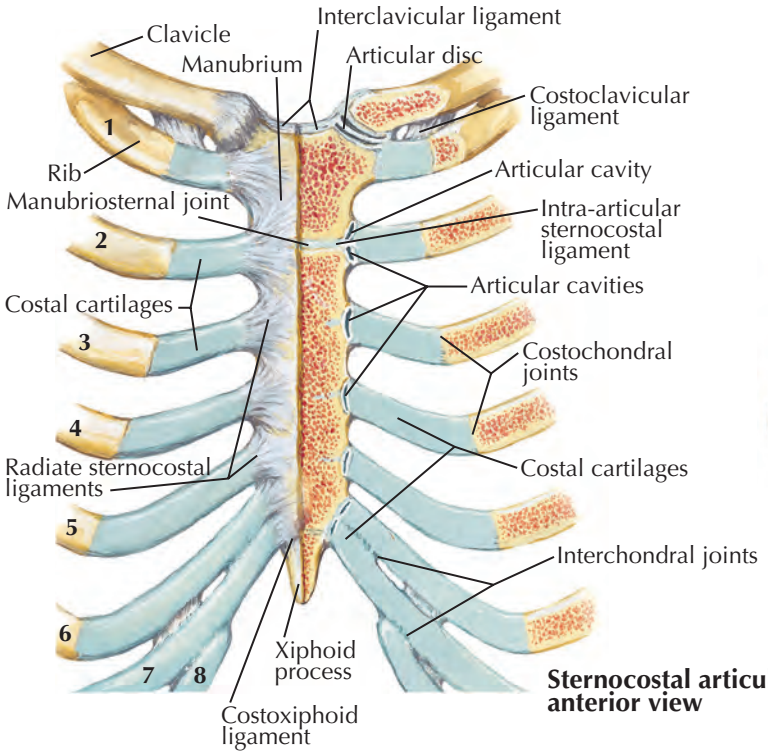

Parasternal nodes
Apical axillary (subclavian) nodes
Interpectoral (Rotter's) nodes
Central axillary nodes
Lateral axillary (humeral) nodes
Posterior axillary (subscapular) nodes
Anterior axillary (pectoral) nodes
Pathway to anterior mediastinal nodes
Pathways to/from opposite breast
Pathways to inferior phrenic (subdiaphragmatic) nodes and liver

Lymphatic Drainage of Breast

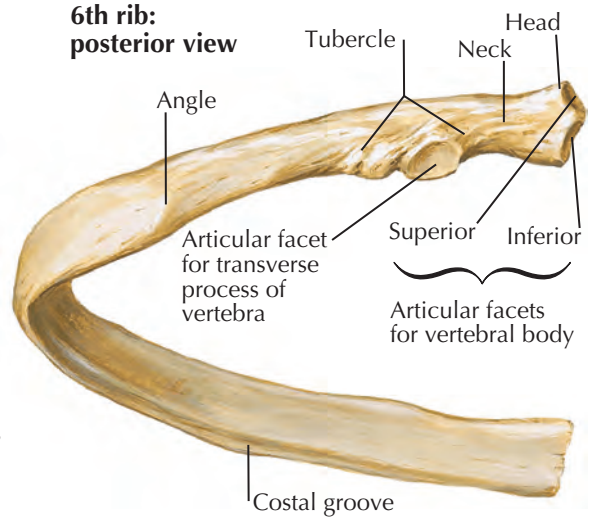
See also Plate 181



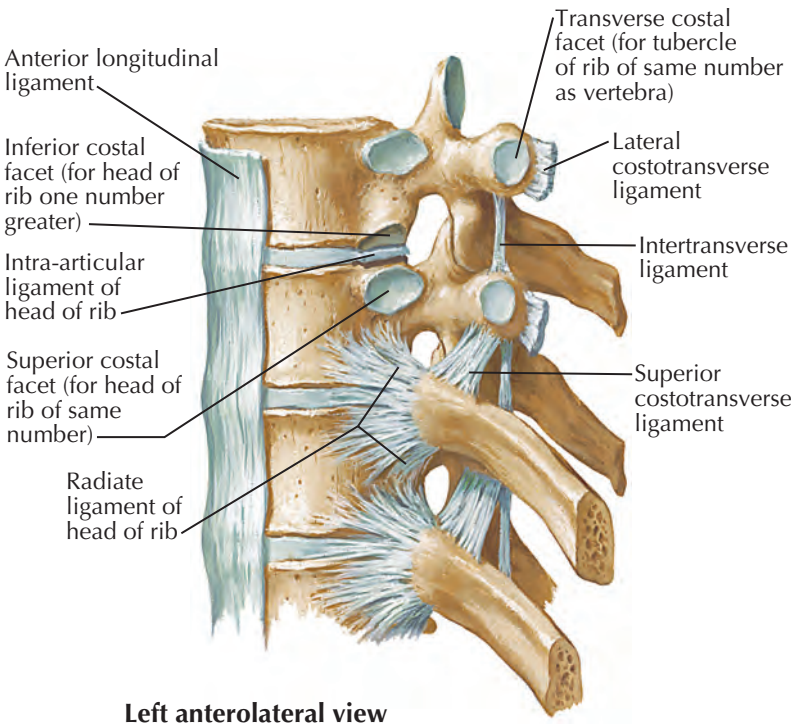

Anterior view
Acromion
Coracoid process
Glenoid cavity
Neck
Suprascapular notch
Subscapular fossa
Scapula
Clavicle
True ribs (1–7)
Costal cartilages
False ribs (8–12)
Jugular notch
Manubrium
Angle
Body
Xiphoid process
Sternum
Floating ribs (11–12)
1
2
3
4
5
6
7
8
9
10
11
12
Posterior view
Head
Neck
Tubercle
Angle
Body
Rib
Clavicle
Acromion
Supraspinous fossa
Spine
Infraspinous fossa
Scapula
True ribs (1–7)
False ribs (8–12)
Floating ribs (11–12)



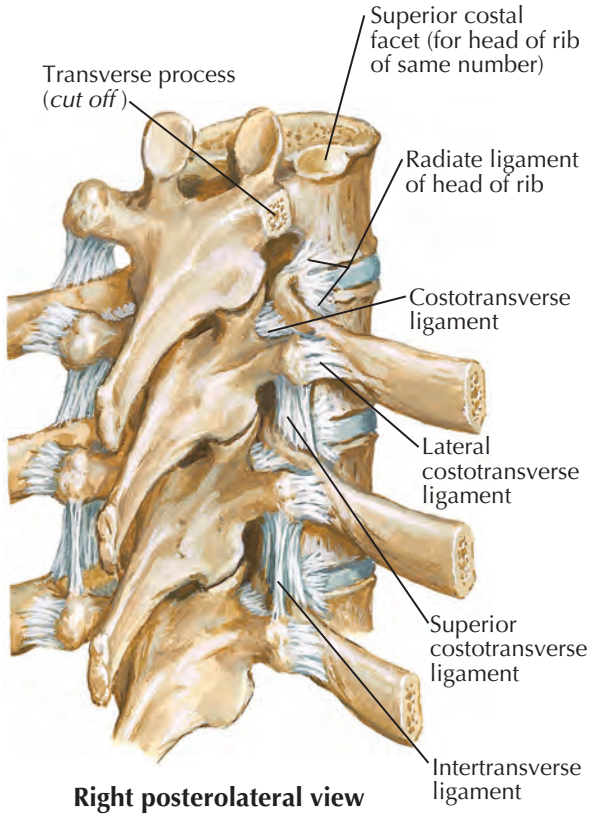
Sternocostal articulations: anterior view



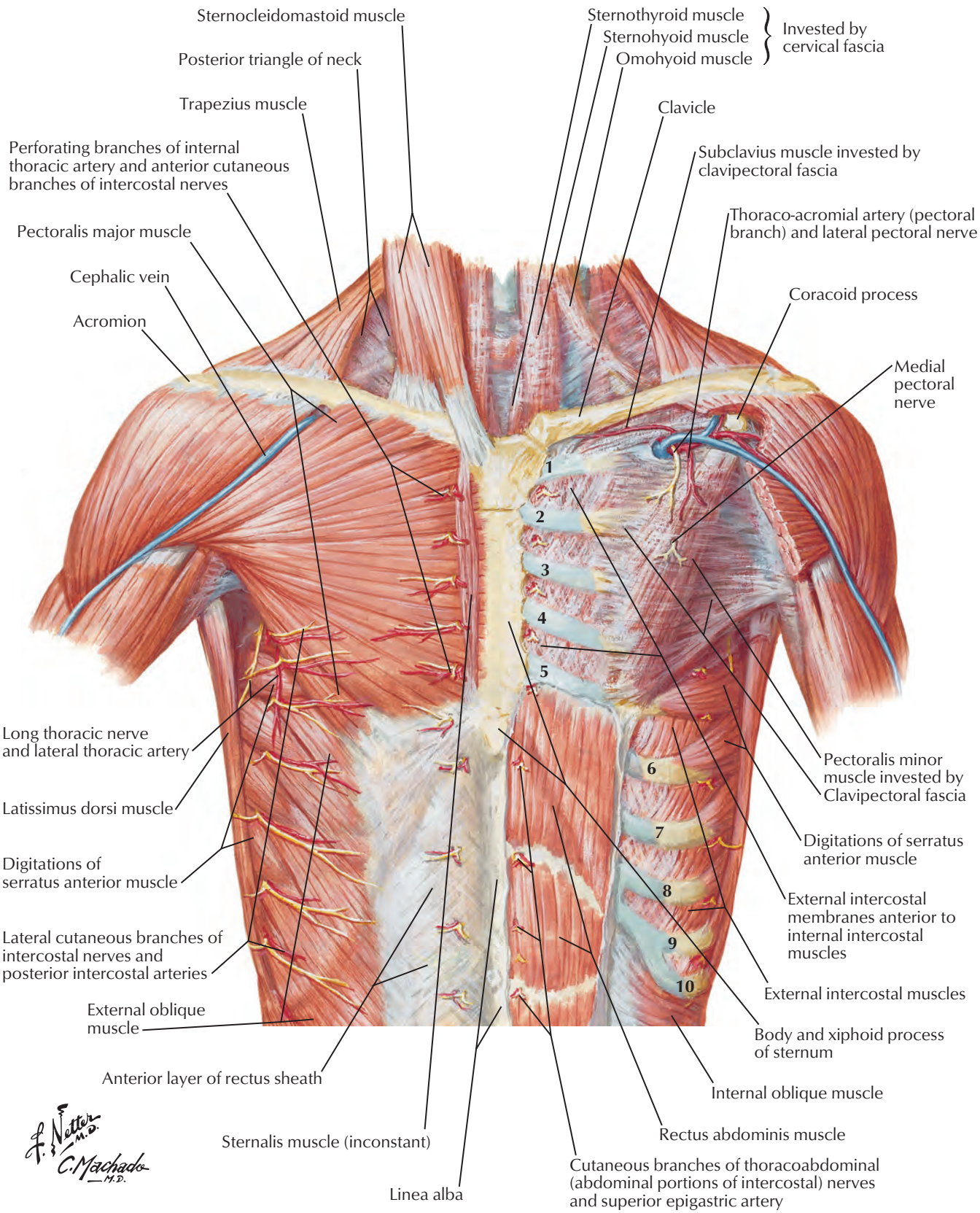
Note: The head of a typical rib articulates with the superior costal facet of the thoracic vertebra of the same number (by its inferior articular facet), the inferior costal facet of the vertebra above (by its superior articular facet), and the intervertebral disc between the two vertebrae. The costal tubercle articulates with the transverse process of the vertebra of the same number.

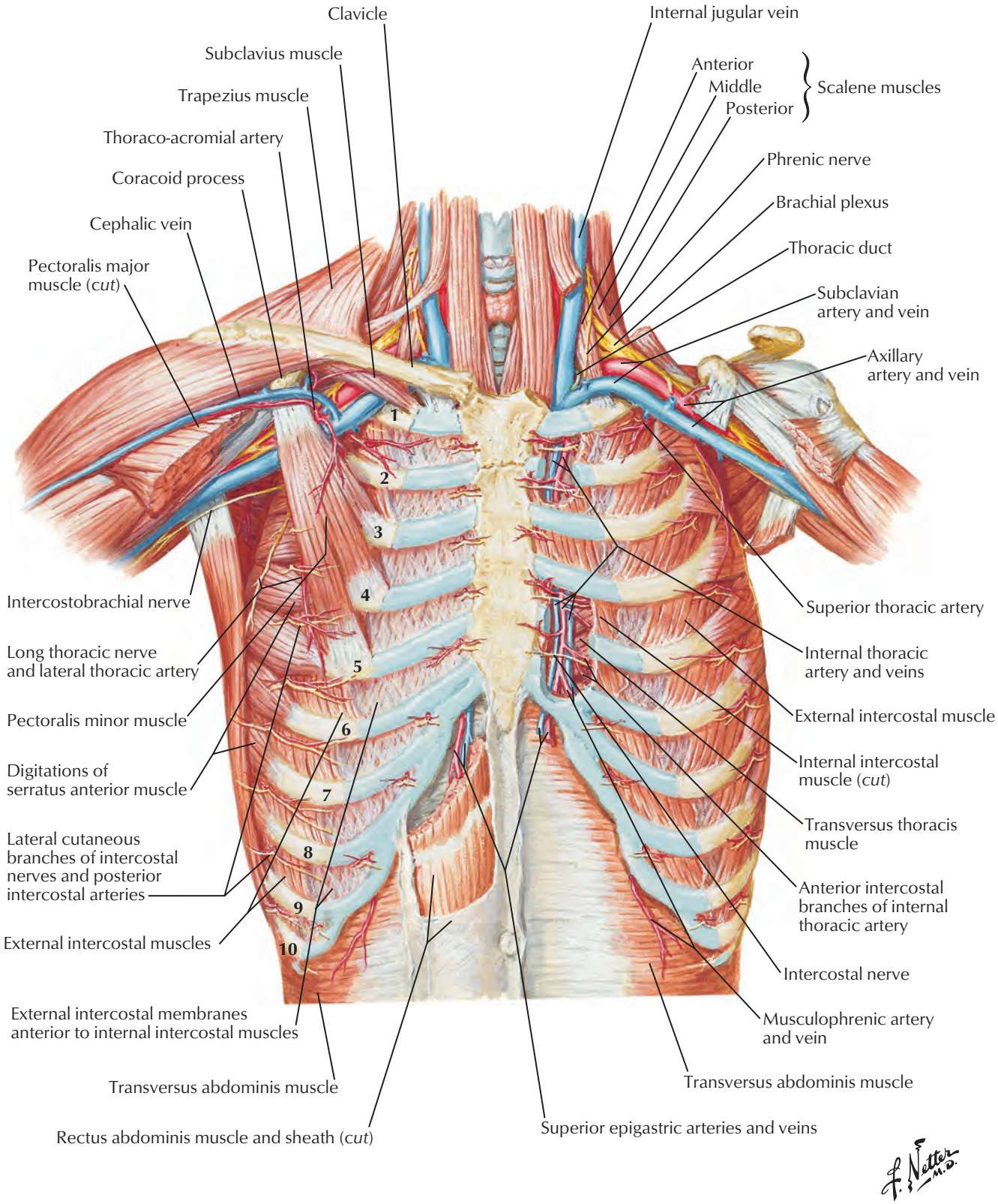


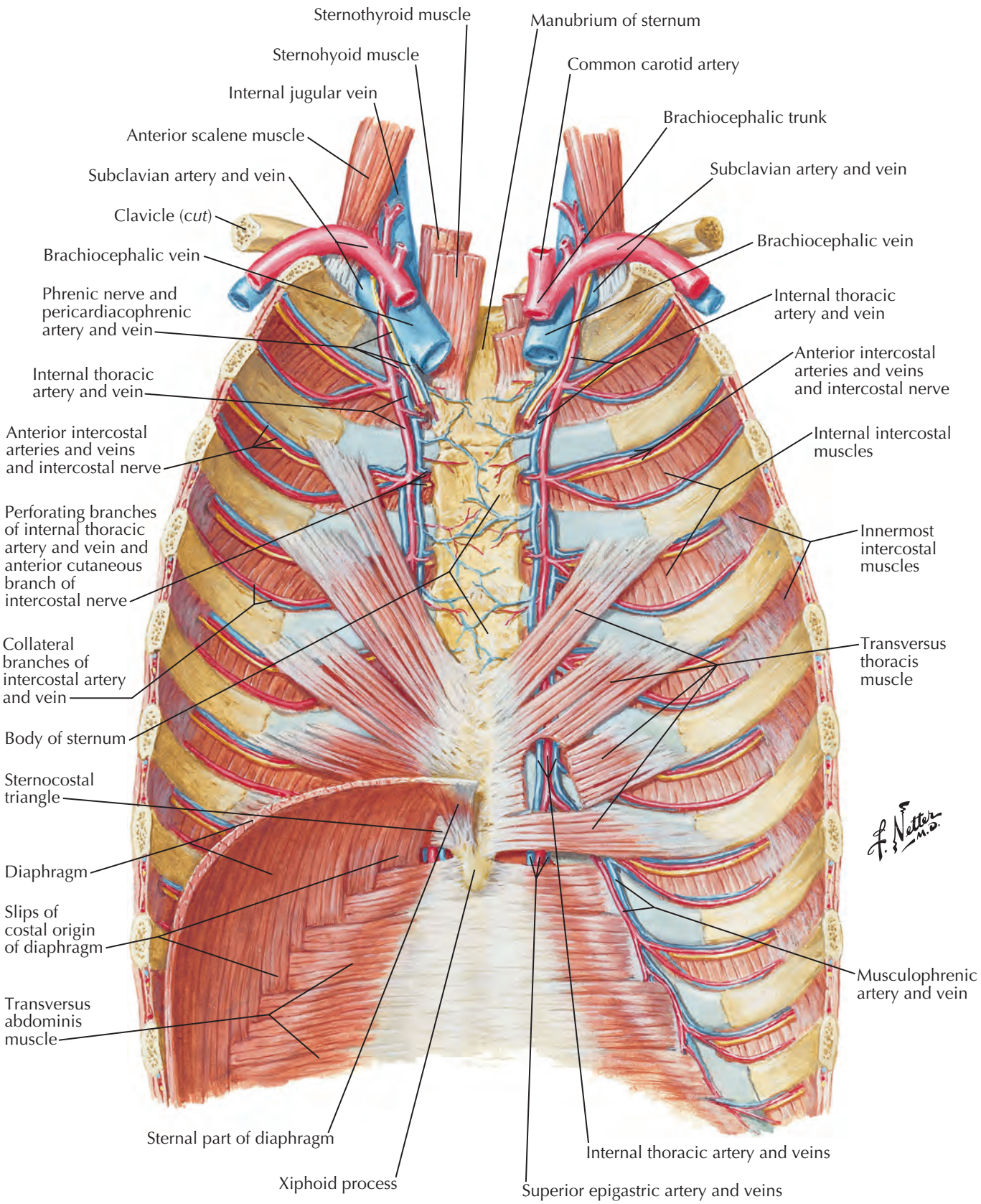
Left anterolateral view

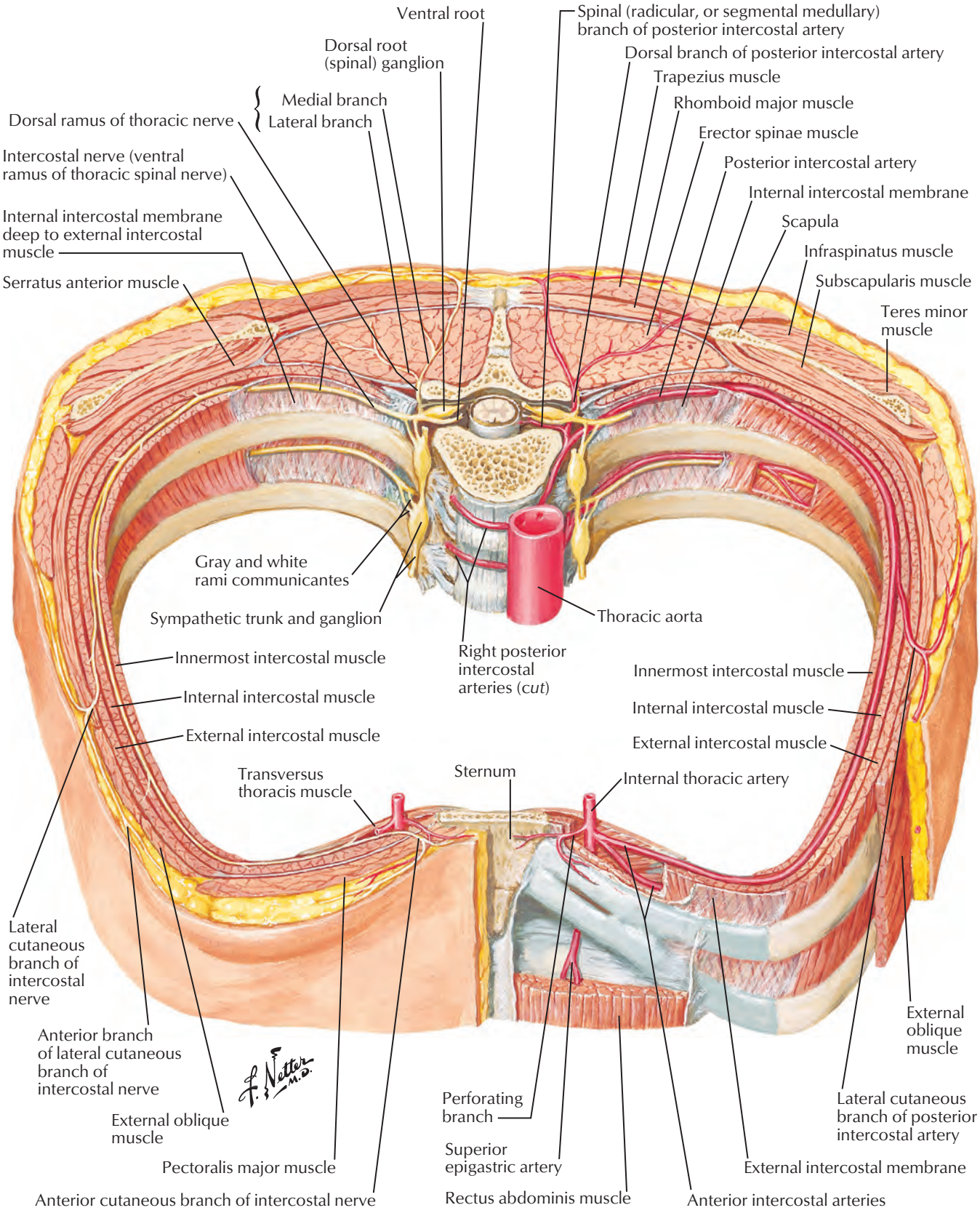


Right posterolateral view


Sternocleidomastoid muscle
Posterior triangle of neck
Trapezius muscle
Perforating branches of internal thoracic artery and anterior cutaneous branches of intercostal nerves
Pectoralis major muscle
Cephalic vein
Acromion
Sternothyroid muscle
Sternohyoid muscle
Omohyoid muscle
Invested by cervical fascia
Clavicle
Subclavius muscle invested by clavipectoral fascia
Thoraco-acromial artery (pectoral branch) and lateral pectoral nerve
Coracoid process
Medial pectoral nerve
1
2
3
4
5
6
7
8
9
10
Long thoracic nerve and lateral thoracic artery
Latissimus dorsi muscle
Digitations of serratus anterior muscle
Lateral cutaneous branches of intercostal nerves and posterior intercostal arteries
External oblique muscle
Anterior layer of rectus sheath
Sternalis muscle (inconstant)
Linea alba
Pectoralis minor muscle invested by Clavipectoral fascia
Digitations of serratus anterior muscle
External intercostal membranes anterior to internal intercostal muscles
External intercostal muscles
Body and xiphoid process of sternum
Internal oblique muscle
Rectus abdominis muscle
Cutaneous branches of thoracoabdominal (abdominal portions of intercostal) nerves and superior epigastric artery

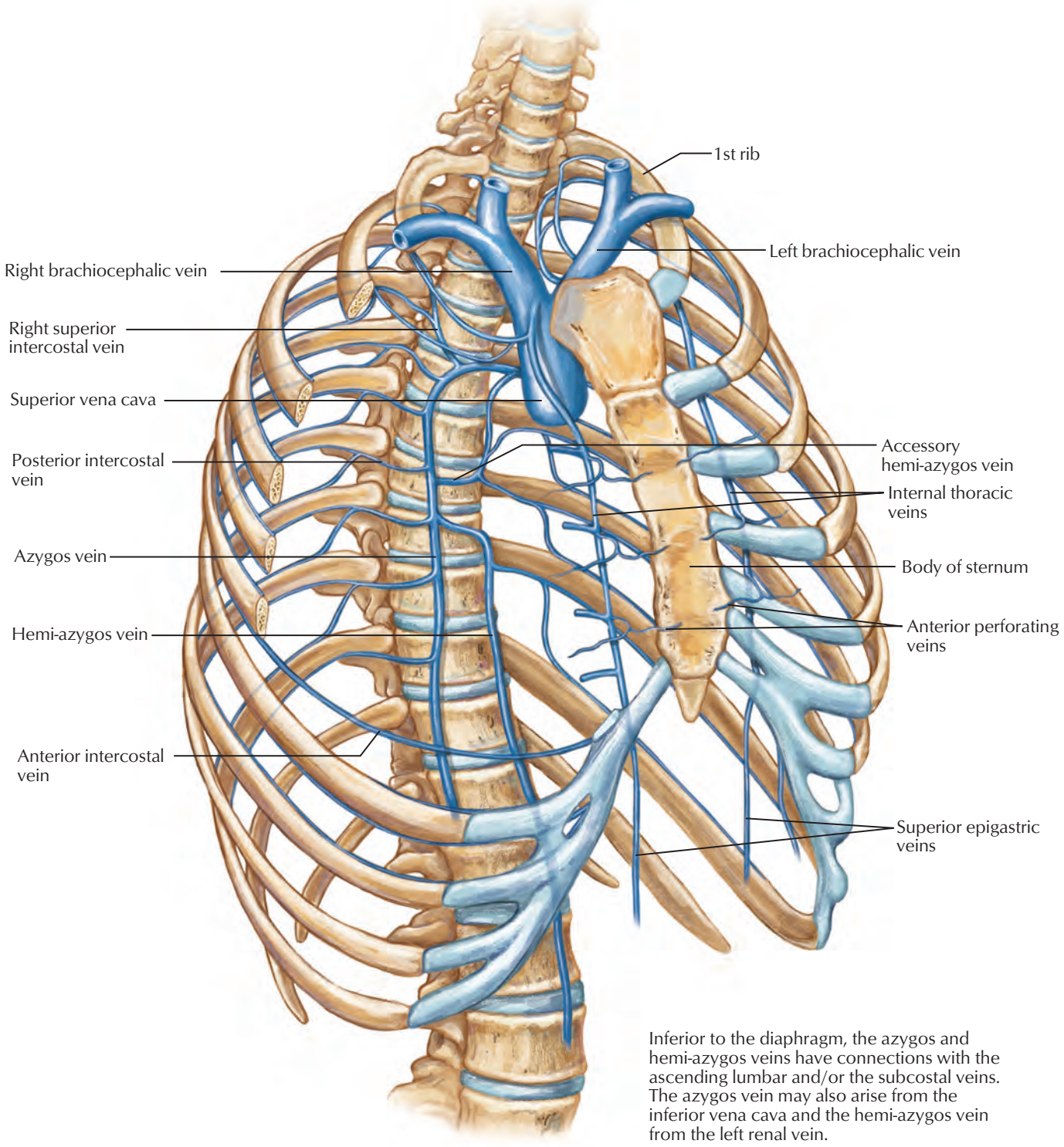

Clavicle
Subclavius muscle
Trapezius muscle
Thoraco-acromial artery
Coracoid process
Cephalic vein
Pectoralis major muscle (cut)
Intercostobrachial nerve
Long thoracic nerve and lateral thoracic artery
Pectoralis minor muscle
Digitations of serratus anterior muscle
Lateral cutaneous branches of intercostal nerves and posterior intercostal arteries
External intercostal muscles
External intercostal membranes anterior to internal intercostal muscles
Transversus abdominis muscle
Rectus abdominis muscle and sheath (cut)
Internal jugular vein
Anterior
Middle
Posterior
Scalene muscles
Phrenic nerve
Brachial plexus
Thoracic duct
Subclavian artery and vein
Axillary artery and vein
Superior thoracic artery
Internal thoracic artery and veins
External intercostal muscle
Internal intercostal muscle (cut)
Transversus thoracis muscle
Anterior intercostal branches of internal thoracic artery
Intercostal nerve
Musculophrenic artery and vein
Transversus abdominis muscle
Superior epigastric arteries and veins
1
2
3
4
5
6
7
8
9
10


Sternothyroid muscle
Manubrium of sternum
Sternohyoid muscle
Common carotid artery
Internal jugular vein
Brachiocephalic trunk
Anterior scalene muscle
Subclavian artery and vein
Subclavian artery and vein
Clavicle (*cut*)
Brachiocephalic vein
Brachiocephalic vein
Phrenic nerve and pericardiacophrenic artery and vein
Internal thoracic artery and vein
Anterior intercostal arteries and veins and intercostal nerve
Internal thoracic artery and vein
Anterior intercostal arteries and veins and intercostal nerve
Internal intercostal muscles
Perforating branches of internal thoracic artery and vein and anterior cutaneous branch of intercostal nerve
Innermost intercostal muscles
Collateral branches of intercostal artery and vein
Transversus thoracis muscle
Body of sternum
Sternocostal triangle
Diaphragm
Slips of costal origin of diaphragm
Musculophrenic artery and vein
Transversus abdominis muscle
Sternal part of diaphragm
Internal thoracic artery and veins
Xiphoid process
Superior epigastric artery and veins

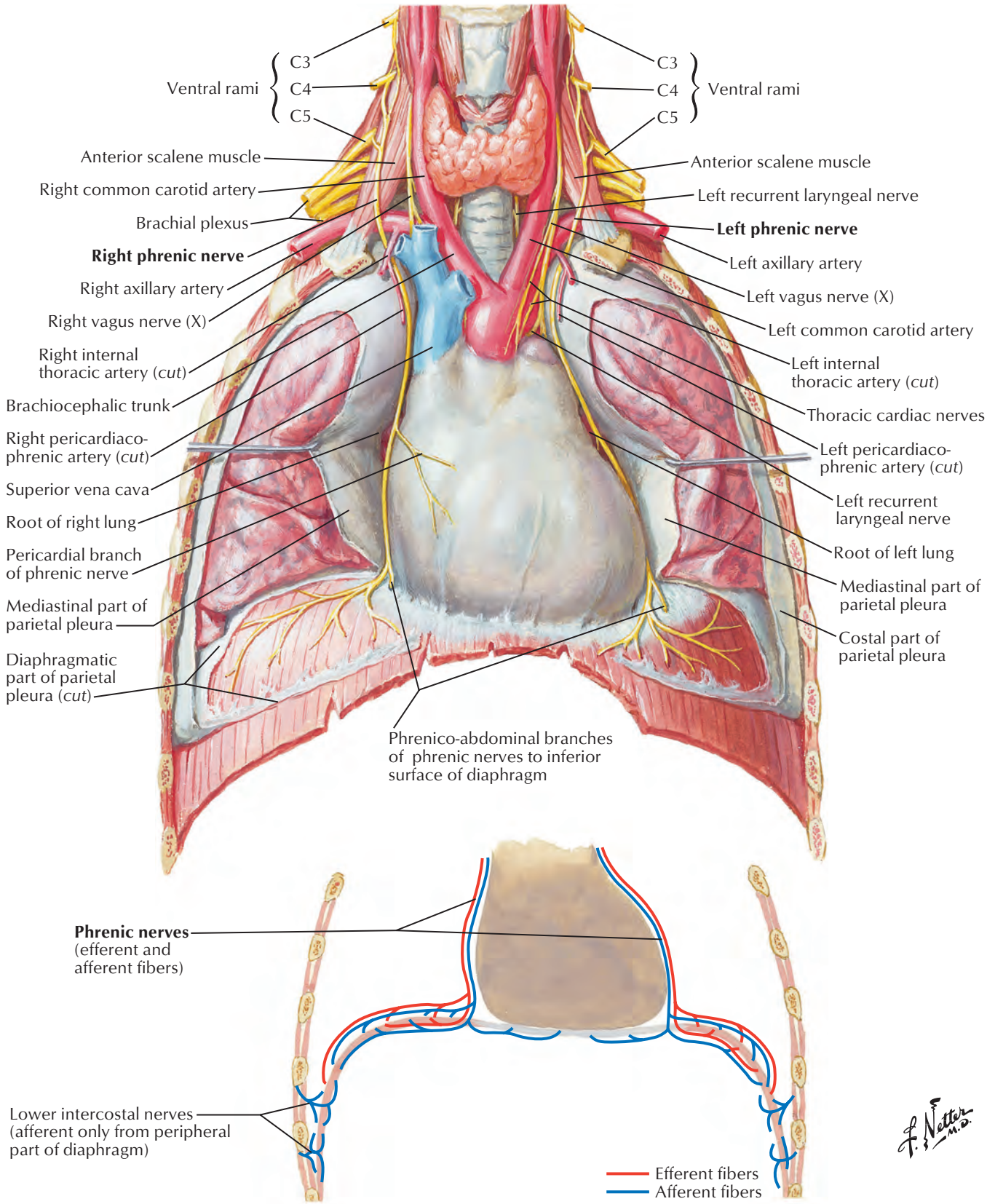

Ventral root
Dorsal root (spinal) ganglion
Spinal (radicular, or segmental medullary) branch of posterior intercostal artery
Dorsal branch of posterior intercostal artery
Trapezius muscle
Rhomboid major muscle
Erector spinae muscle
Posterior intercostal artery
Internal intercostal membrane
Scapula
Infraspinatus muscle
Subscapularis muscle
Teres minor muscle
Medial branch
Lateral branch
Dorsal ramus of thoracic nerve
Intercostal nerve (ventral ramus of thoracic spinal nerve)
Internal intercostal membrane deep to external intercostal muscle
Serratus anterior muscle
Gray and white rami communicantes
Sympathetic trunk and ganglion
Thoracic aorta
Right posterior intercostal arteries (cut)
Innermost intercostal muscle
Internal intercostal muscle
External intercostal muscle
Transversus thoracis muscle
Sternum
Internal thoracic artery
Innermost intercostal muscle
Internal intercostal muscle
External intercostal muscle
Lateral cutaneous branch of intercostal nerve
Anterior branch of lateral cutaneous branch of intercostal nerve
External oblique muscle
Pectoralis major muscle
Anterior cutaneous branch of intercostal nerve
Perforating branch
Superior epigastric artery
Rectus abdominis muscle
Anterior intercostal arteries
External intercostal membrane
Lateral cutaneous branch of posterior intercostal artery
External oblique muscle

Veins of Internal Thoracic Wall

See also Plates 187, 227, 252

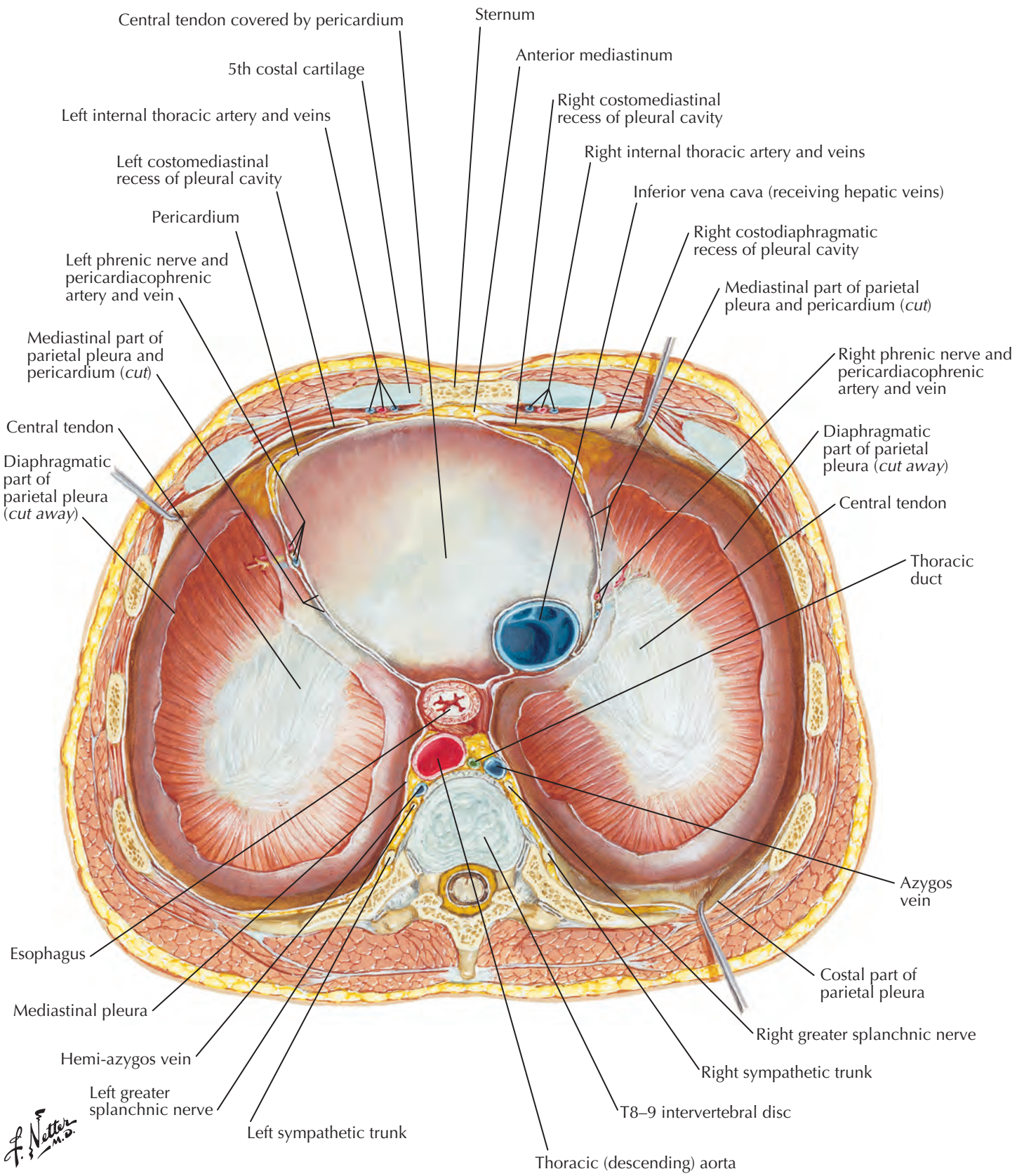


Inferior to the diaphragm, the azygos and hemi-azygos veins have connections with the ascending lumbar and/or the subcostal veins. The azygos vein may also arise from the inferior vena cava and the hemi-azygos vein from the left renal vein.


Ventral rami
C3
C4
C5
C3
C4
C5
Ventral rami
Anterior scalene muscle
Right common carotid artery
Brachial plexus
Right phrenic nerve
Right axillary artery
Right vagus nerve (X)
Right internal thoracic artery (*cut*)
Brachiocephalic trunk
Right pericardiaco-phrenic artery (*cut*)
Superior vena cava
Root of right lung
Pericardial branch of phrenic nerve
Mediastinal part of parietal pleura
Diaphragmatic part of parietal pleura (*cut*)
Anterior scalene muscle
Left recurrent laryngeal nerve
Left phrenic nerve
Left axillary artery
Left vagus nerve (X)
Left common carotid artery
Left internal thoracic artery (*cut*)
Thoracic cardiac nerves
Left pericardiaco-phrenic artery (*cut*)
Left recurrent laryngeal nerve
Root of left lung
Mediastinal part of parietal pleura
Costal part of parietal pleura
Phrenico-abdominal branches of phrenic nerves to inferior surface of diaphragm
Phrenic nerves (efferent and afferent fibers)
Lower intercostal nerves (afferent only from peripheral part of diaphragm)
Efferent fibers
Afferent fibers

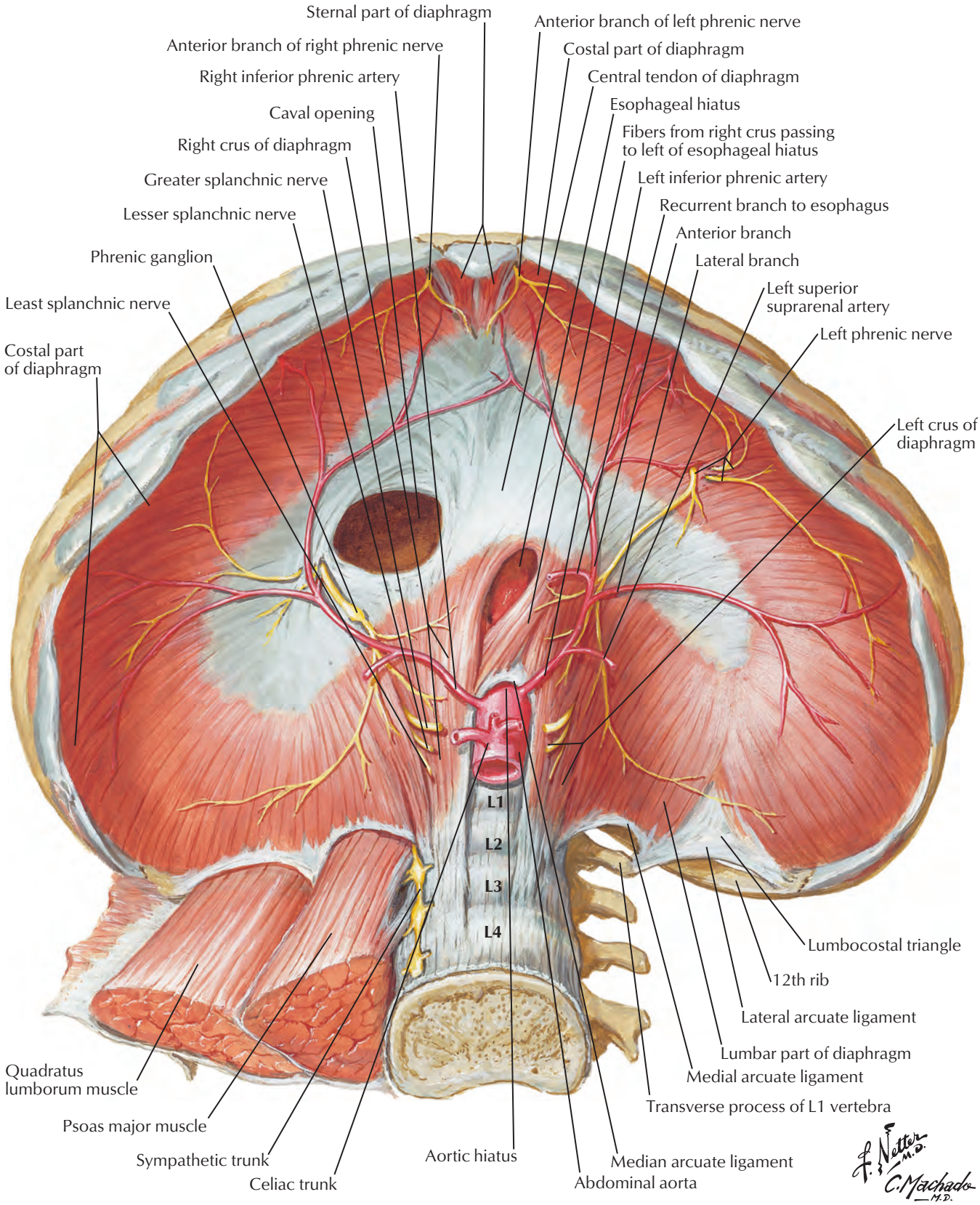
Diaphragm: Thoracic Surface

See also Plate 229

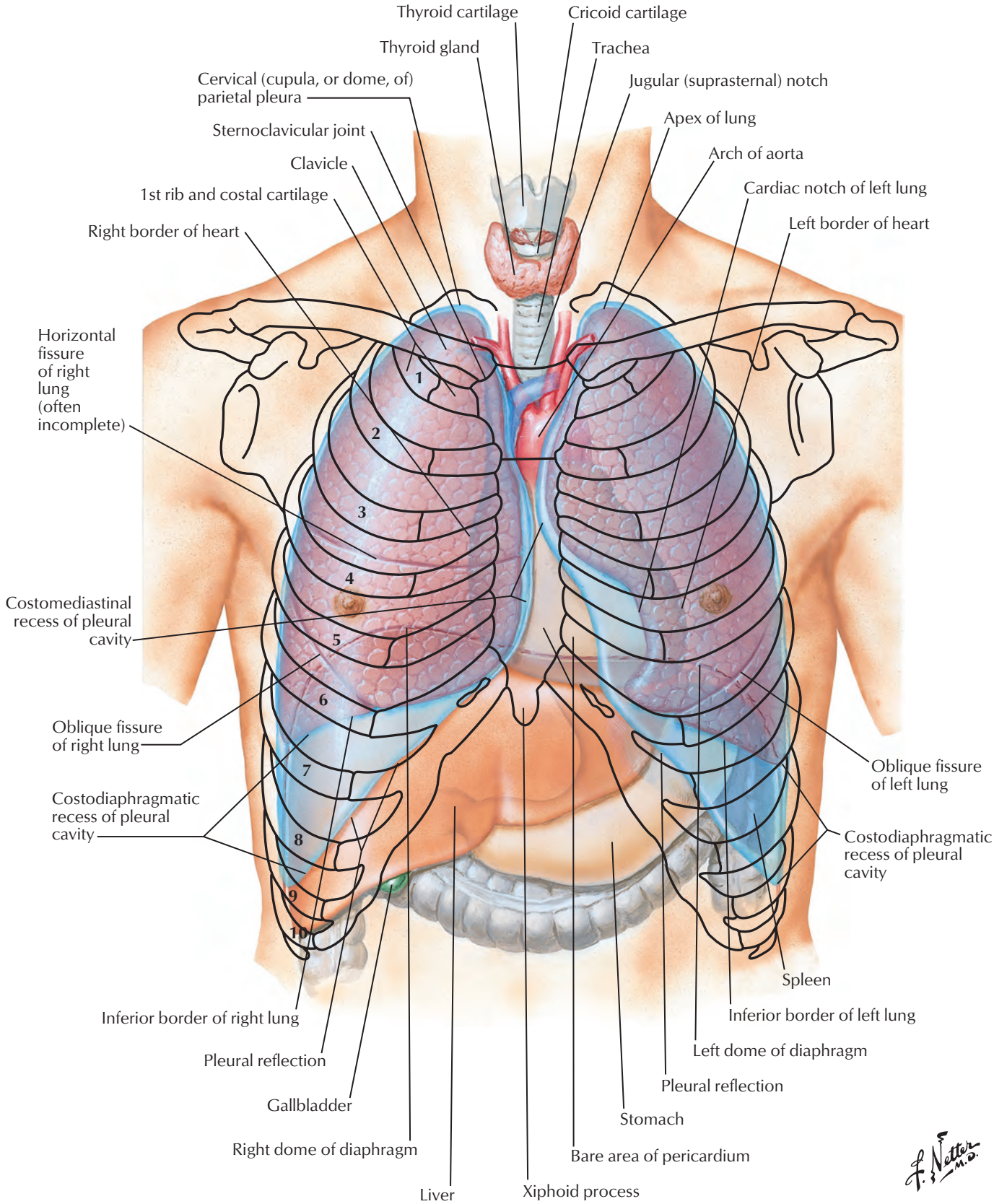


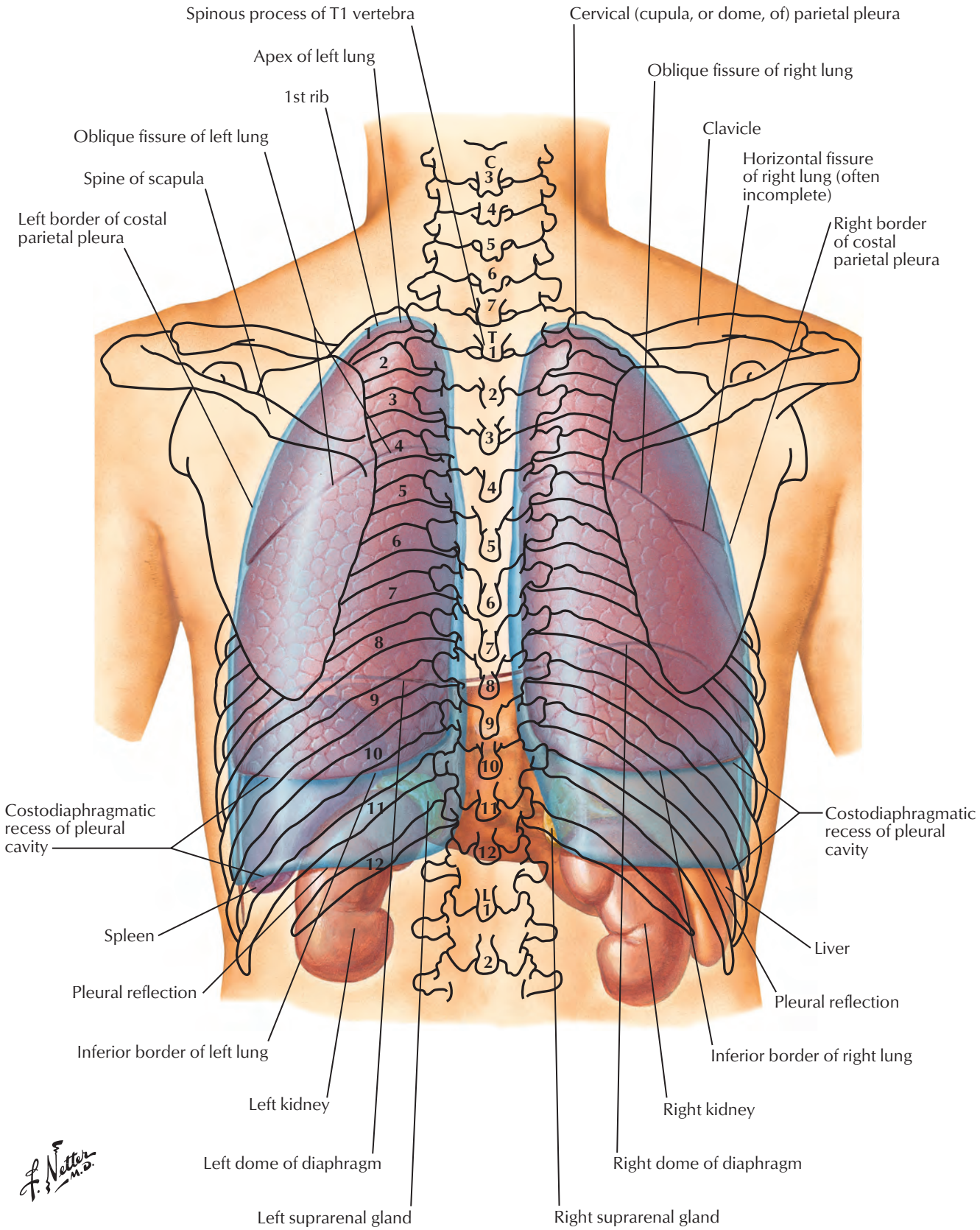
Diaphragm: Abdominal Surface

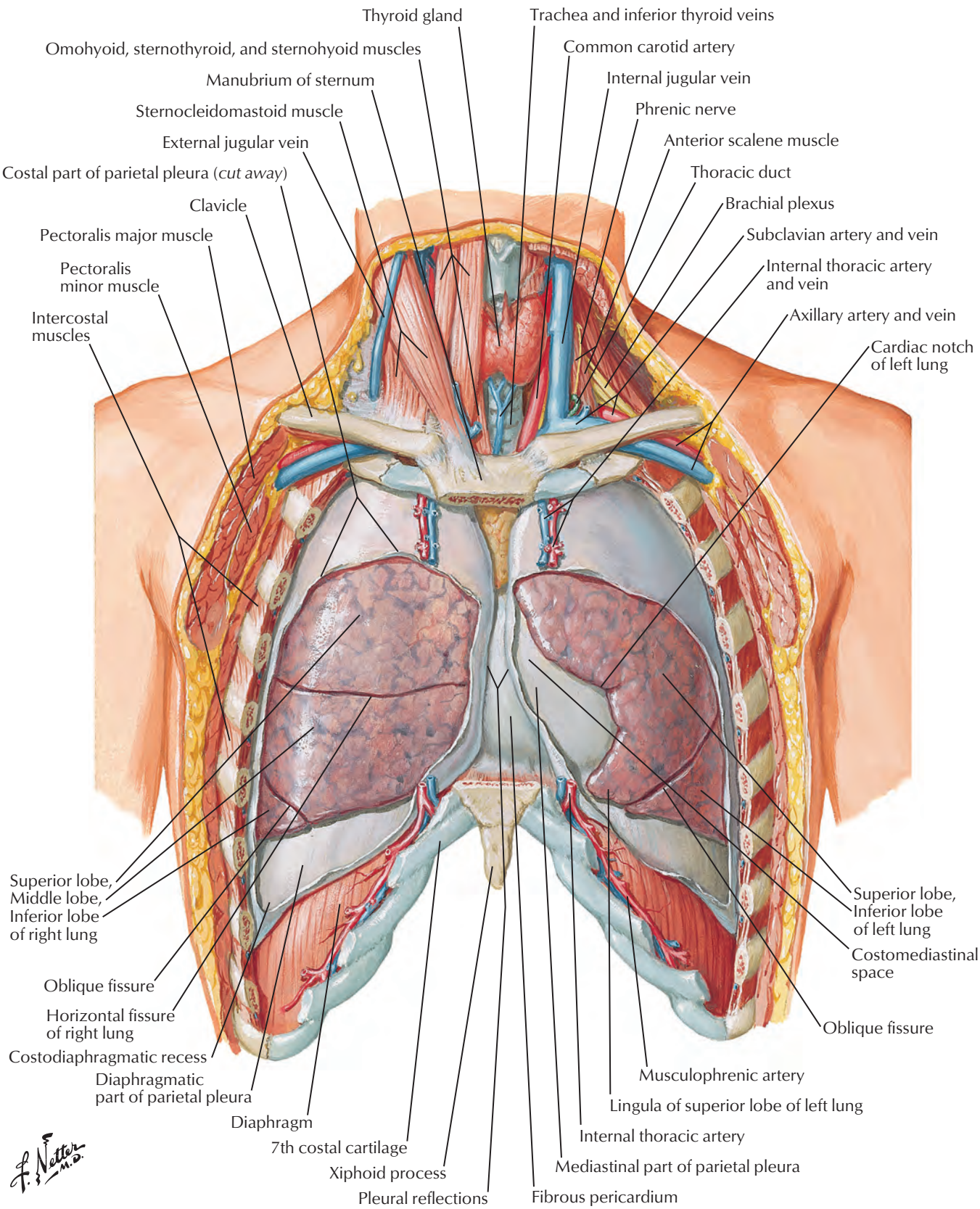
See also **Plates 258, 259**

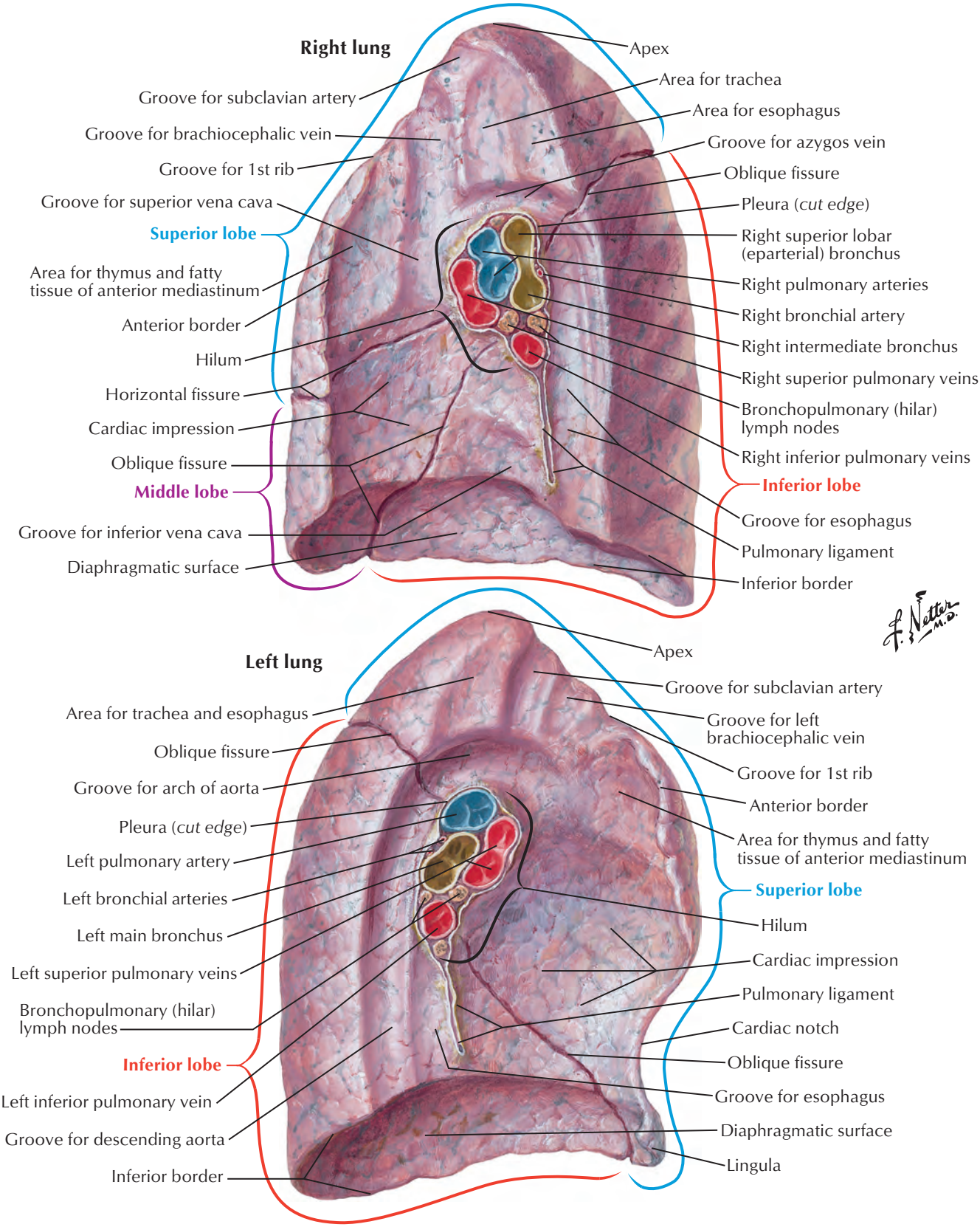


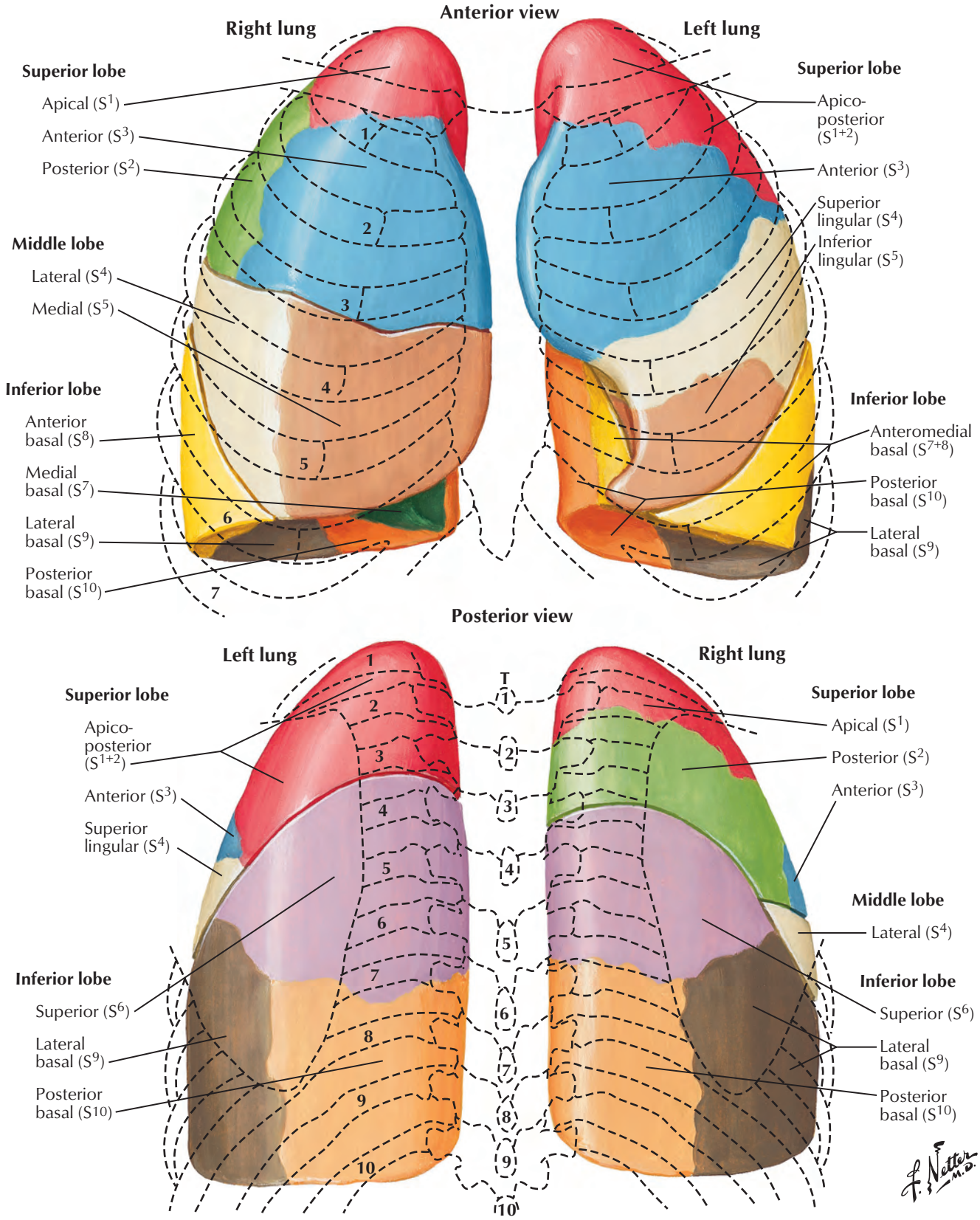
Topography of Lungs: Anterior View



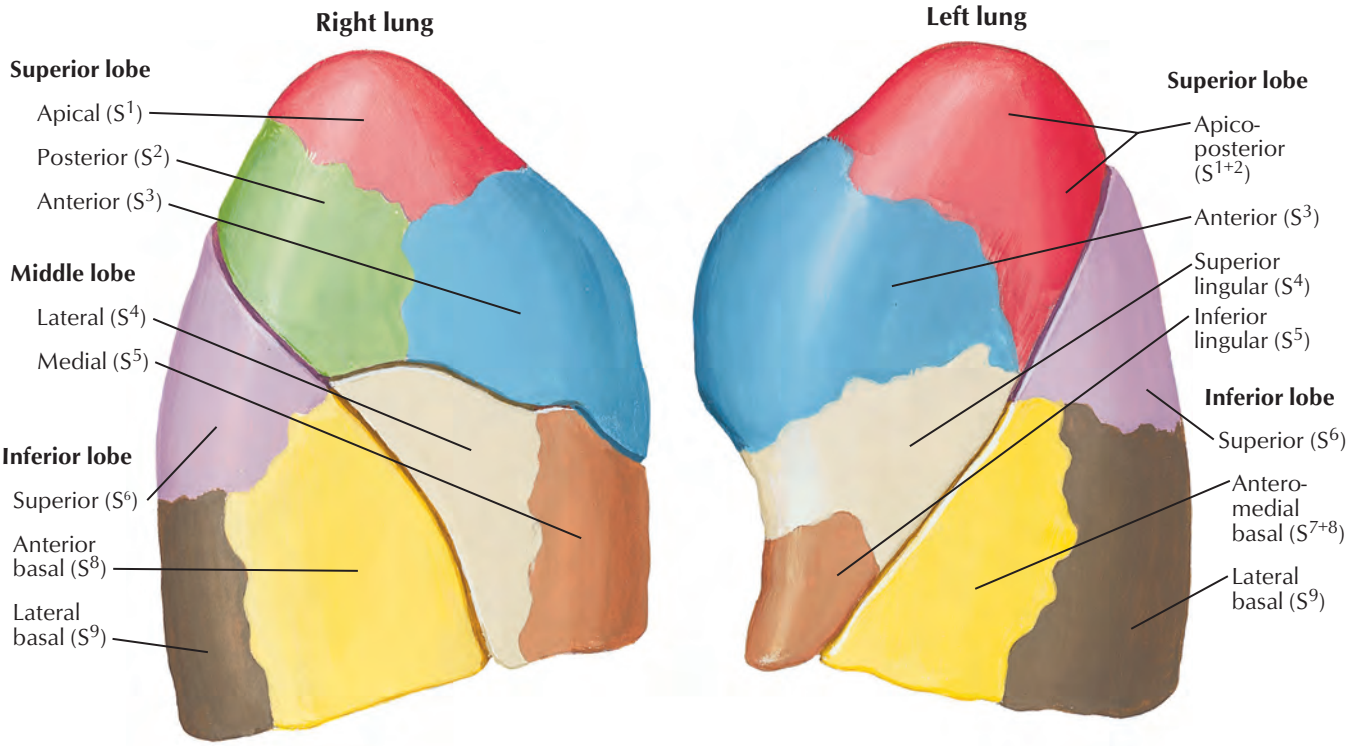

Spinous process of T1 vertebra
Cervical (cupula, or dome, of) parietal pleura
Apex of left lung
Oblique fissure of right lung
1st rib
Clavicle
Oblique fissure of left lung
Horizontal fissure of right lung (often incomplete)
Spine of scapula
Left border of costal parietal pleura
Right border of costal parietal pleura
C 3
4
5
6
7
T 1
2
3
4
5
6
7
8
9
10
11
12
L 1
2
1
2
3
4
5
6
7
8
9
10
11
12
Costodiaphragmatic recess of pleural cavity
Costodiaphragmatic recess of pleural cavity
Spleen
Liver
Pleural reflection
Pleural reflection
Inferior border of left lung
Inferior border of right lung
Left kidney
Right kidney
Left dome of diaphragm
Right dome of diaphragm
Left suprarenal gland
Right suprarenal gland


Thyroid gland
Trachea and inferior thyroid veins
Omohyoid, sternothyroid, and sternohyoid muscles
Common carotid artery
Manubrium of sternum
Internal jugular vein
Sternocleidomastoid muscle
Phrenic nerve
External jugular vein
Anterior scalene muscle
Costal part of parietal pleura (cut away)
Thoracic duct
Clavicle
Brachial plexus
Pectoralis major muscle
Subclavian artery and vein
Pectoralis minor muscle
Internal thoracic artery and vein
Intercostal muscles
Axillary artery and vein
Cardiac notch of left lung
Superior lobe, Middle lobe, Inferior lobe of right lung
Superior lobe, Inferior lobe of left lung
Costomediastinal space
Oblique fissure
Horizontal fissure of right lung
Oblique fissure
Costodiaphragmatic recess
Musculophrenic artery
Diaphragmatic part of parietal pleura
Lingula of superior lobe of left lung
Diaphragm
Internal thoracic artery
7th costal cartilage
Mediastinal part of parietal pleura
Xiphoid process
Pleural reflections
Fibrous pericardium

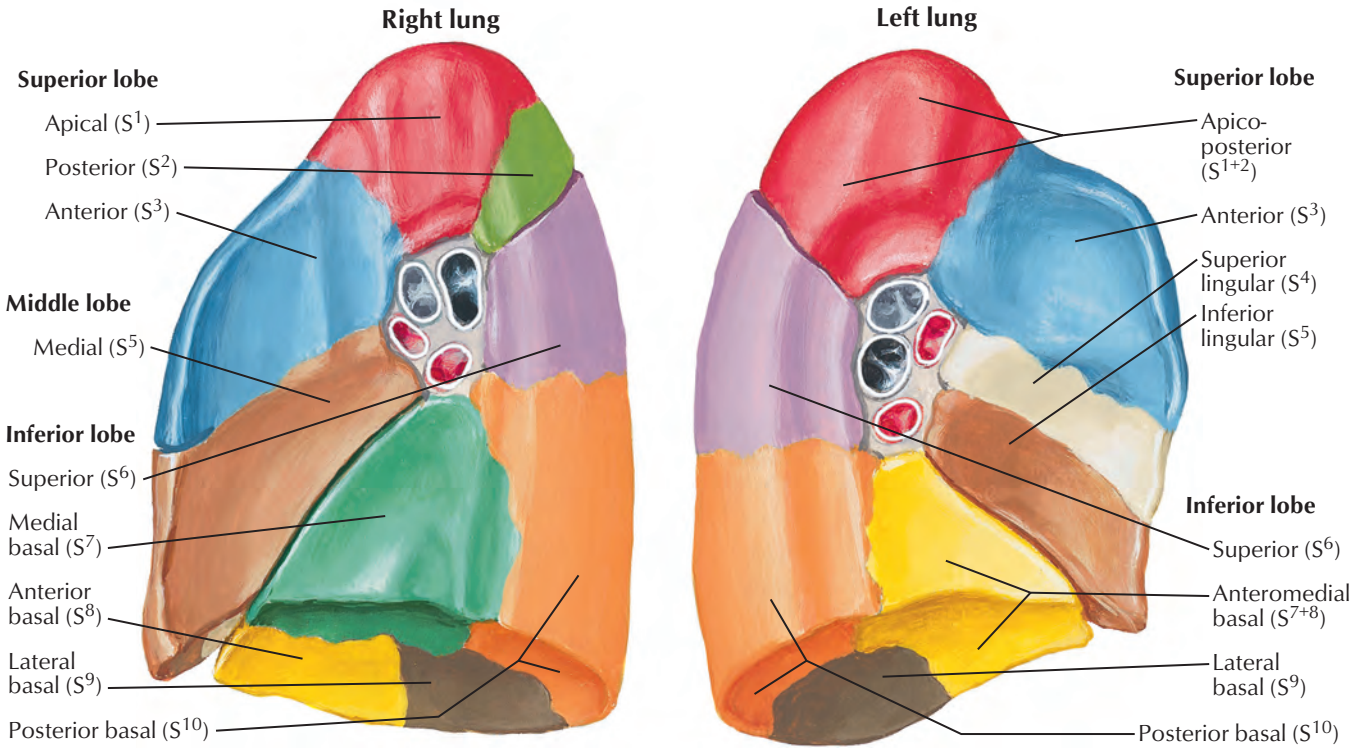

Right lung
Apex
Area for trachea
Area for esophagus
Groove for azygos vein
Oblique fissure
Pleura (cut edge)
Right superior lobar (eparterial) bronchus
Right pulmonary arteries
Right bronchial artery
Right intermediate bronchus
Right superior pulmonary veins
Bronchopulmonary (hilar) lymph nodes
Right inferior pulmonary veins
Inferior lobe
Groove for esophagus
Pulmonary ligament
Inferior border
Groove for subclavian artery
Groove for brachiocephalic vein
Groove for 1st rib
Groove for superior vena cava
Superior lobe
Area for thymus and fatty tissue of anterior mediastinum
Anterior border
Hilum
Horizontal fissure
Cardiac impression
Oblique fissure
Middle lobe
Groove for inferior vena cava
Diaphragmatic surface
F. Netter M.D.
Left lung
Apex
Groove for subclavian artery
Groove for left brachiocephalic vein
Groove for 1st rib
Anterior border
Area for thymus and fatty tissue of anterior mediastinum
Superior lobe
Hilum
Cardiac impression
Pulmonary ligament
Cardiac notch
Oblique fissure
Groove for esophagus
Diaphragmatic surface
Lingula
Area for trachea and esophagus
Oblique fissure
Groove for arch of aorta
Pleura (cut edge)
Left pulmonary artery
Left bronchial arteries
Left main bronchus
Left superior pulmonary veins
Bronchopulmonary (hilar) lymph nodes
Inferior lobe
Left inferior pulmonary vein
Groove for descending aorta
Inferior border

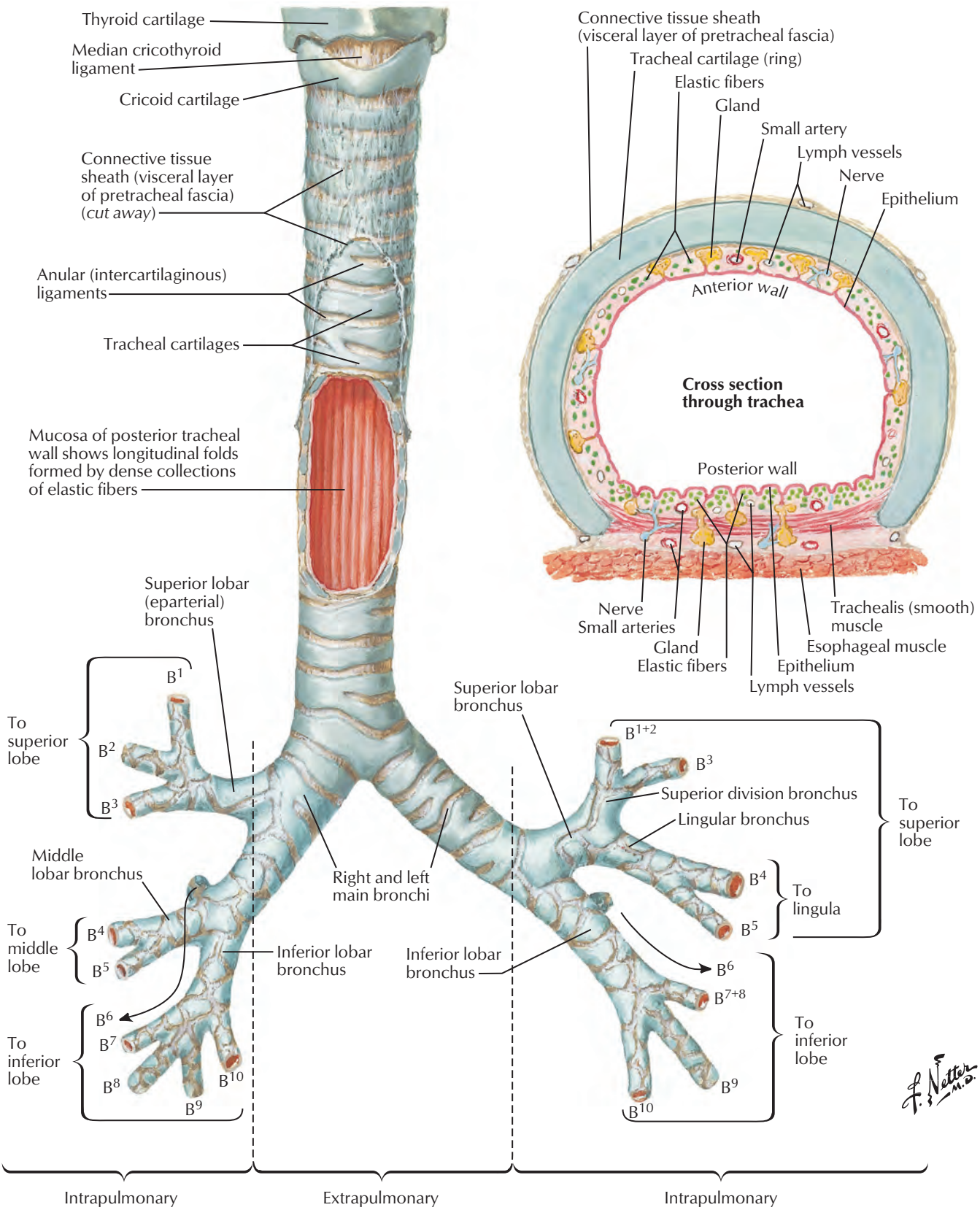

Anterior view
Right lung
Left lung
Superior lobe
Apical (S1)
Anterior (S3)
Posterior (S2)
Middle lobe
Lateral (S4)
Medial (S5)
Inferior lobe
Anterior basal (S8)
Medial basal (S7)
Lateral basal (S9)
Posterior basal (S10)
Superior lobe
Apico-posterior (S1+2)
Anterior (S3)
Superior lingular (S4)
Inferior lingular (S5)
Inferior lobe
Anteromedial basal (S7+8)
Posterior basal (S10)
Lateral basal (S9)
Posterior view
Left lung
Right lung
Superior lobe
Apico-posterior (S1+2)
Anterior (S3)
Superior lingular (S4)
Inferior lobe
Superior (S6)
Lateral basal (S9)
Posterior basal (S10)
Superior lobe
Apical (S1)
Posterior (S2)
Anterior (S3)
Middle lobe
Lateral (S4)
Inferior lobe
Superior (S6)
Lateral basal (S9)
Posterior basal (S10)

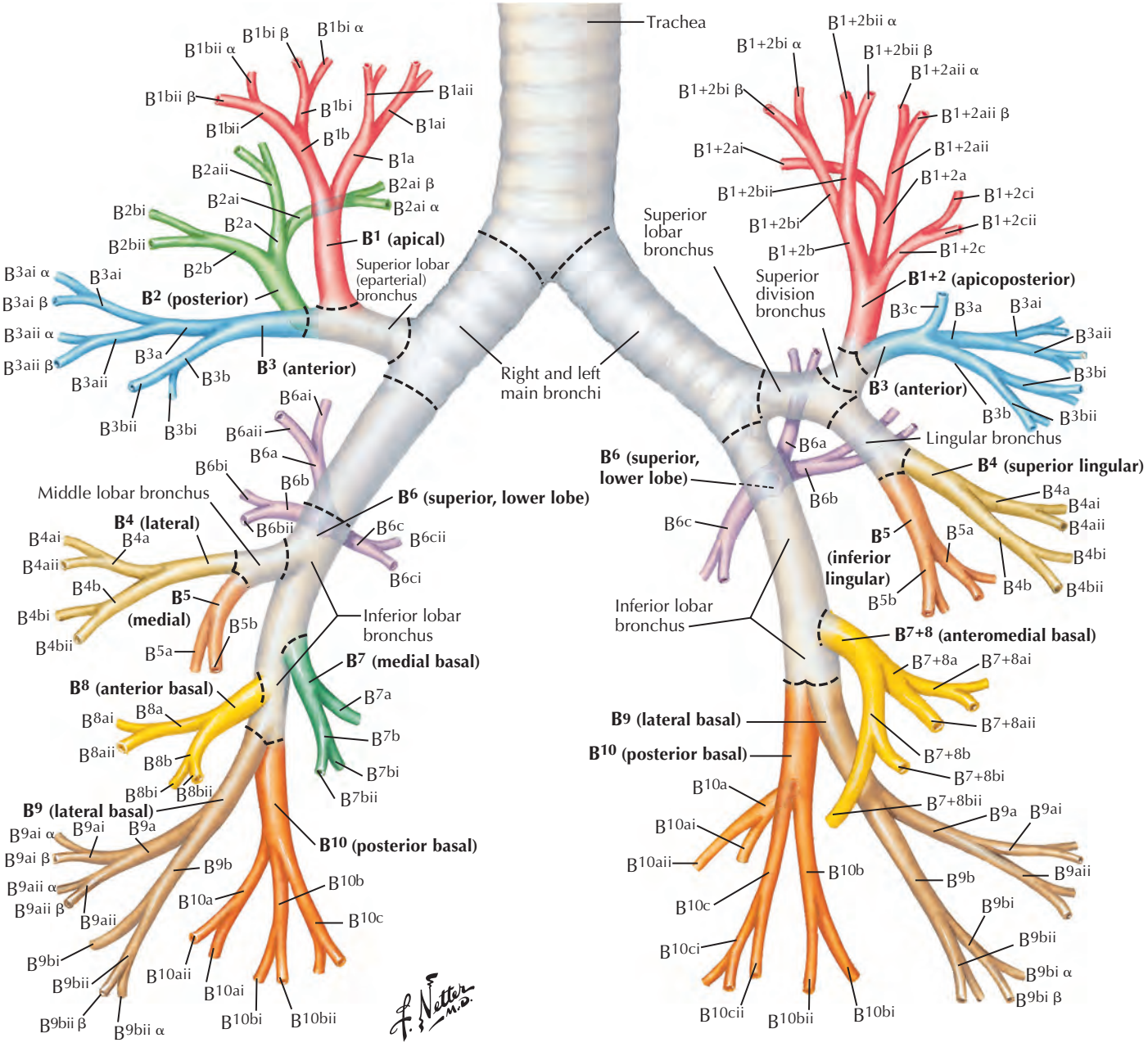
Lateral views



Medial views

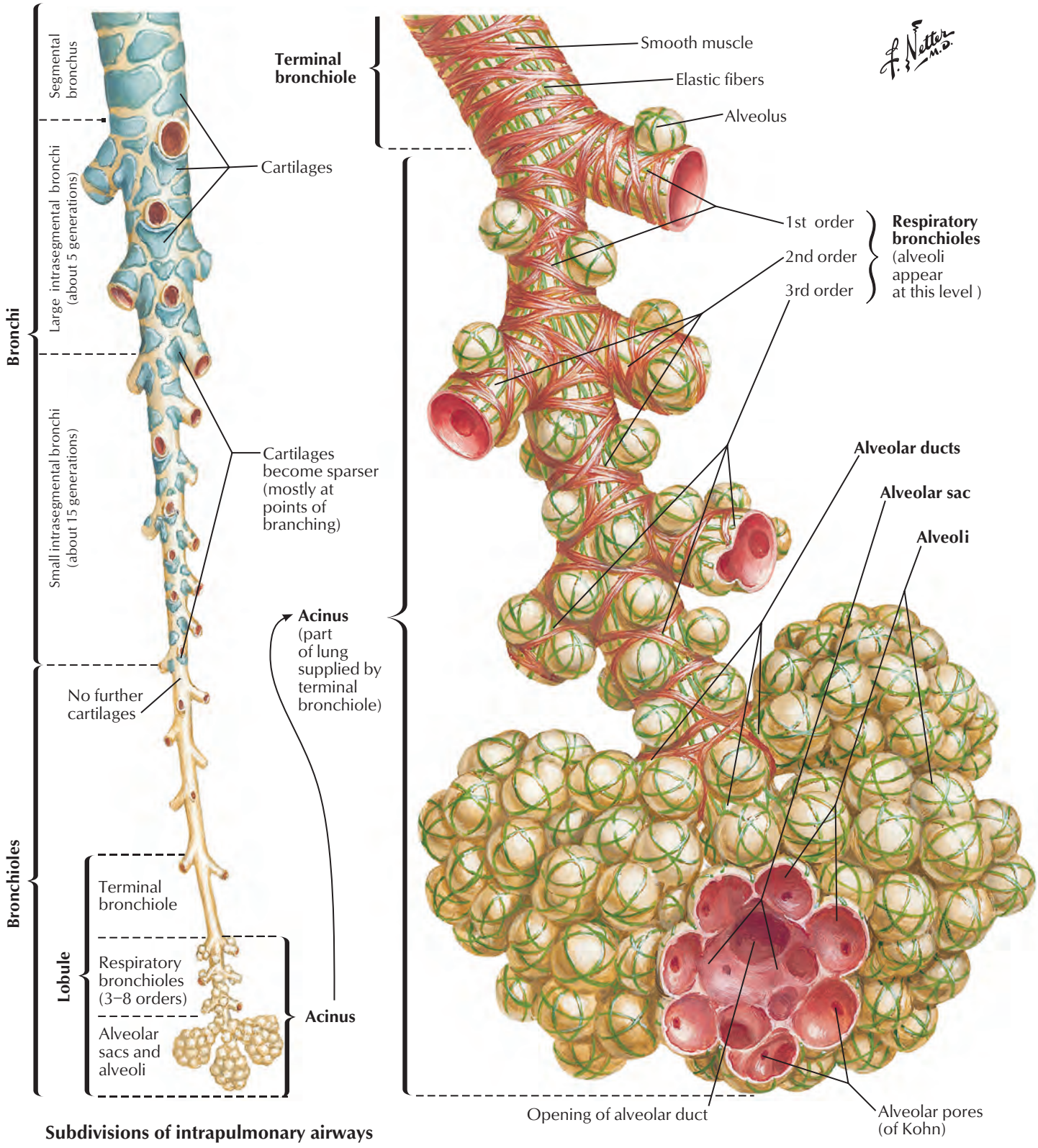



Thyroid cartilage
Median cricothyroid ligament
Cricoid cartilage
Connective tissue sheath (visceral layer of pretracheal fascia) (cut away)
Anular (intercartilaginous) ligaments
Tracheal cartilages
Mucosa of posterior tracheal wall shows longitudinal folds formed by dense collections of elastic fibers
Connective tissue sheath (visceral layer of pretracheal fascia)
Tracheal cartilage (ring)
Elastic fibers
Gland
Small artery
Lymph vessels
Nerve
Epithelium
Anterior wall
Cross section through trachea
Posterior wall
Nerve
Small arteries
Gland
Elastic fibers
Epithelium
Lymph vessels
Trachealis (smooth) muscle
Esophageal muscle
Superior lobar (eparterial) bronchus
Superior lobar bronchus
To superior lobe
B1
B2
B3
B1+2
B3
Superior division bronchus
Lingular bronchus
To superior lobe
B4
B5
To lingula
Middle lobar bronchus
Right and left main bronchi
To middle lobe
B4
B5
Inferior lobar bronchus
Inferior lobar bronchus
B6
B7+8
To inferior lobe
B6
B7
B8
B10
B9
B9
B10
To inferior lobe
Intrapulmonary
Extrapulmonary
Intrapulmonary



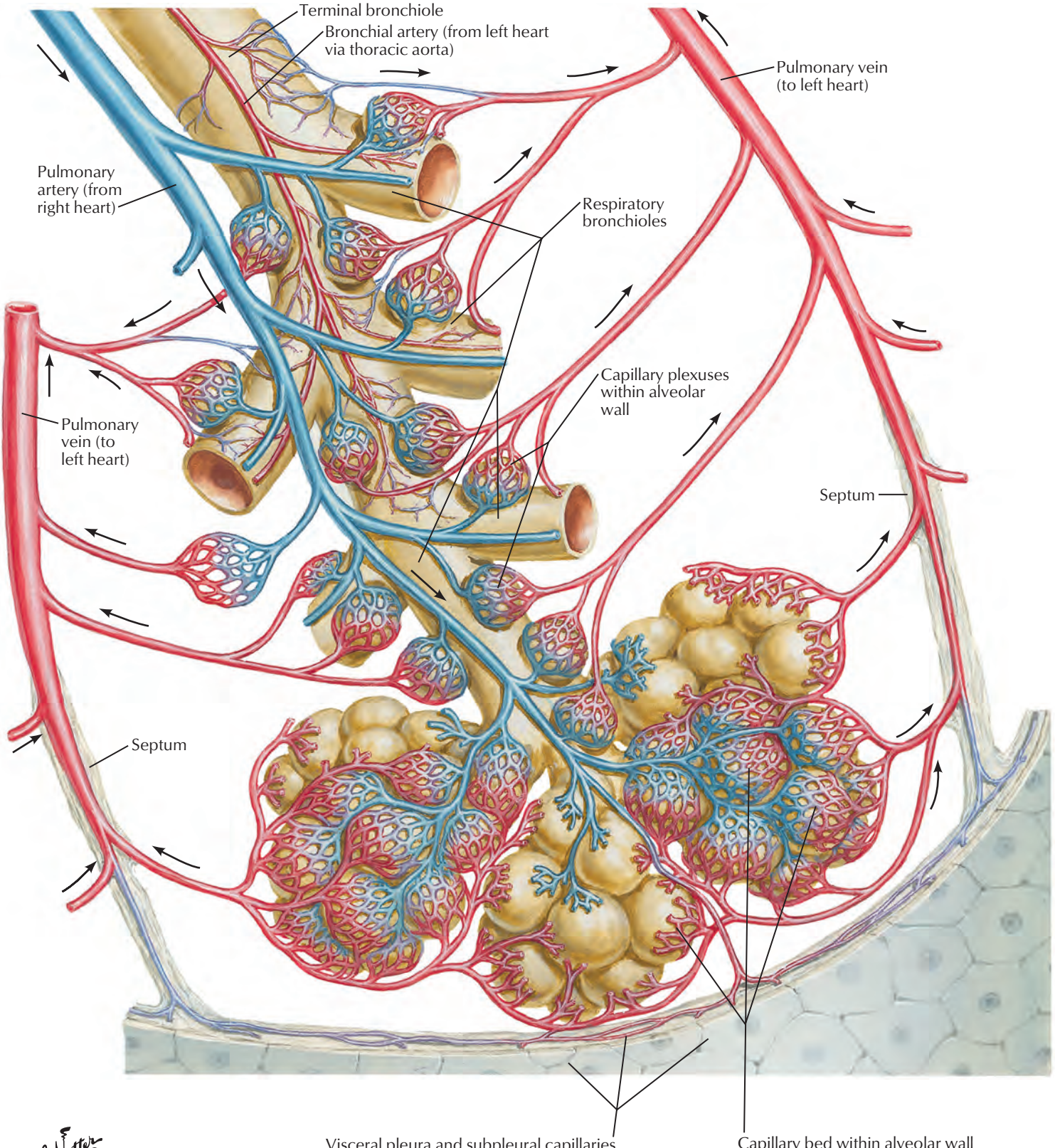
Nomenclature in common usage for bronchopulmonary segments (Plates 197 and 198) is that of Jackson and Huber, and segmental bronchi are named accordingly. Ikeda proposed nomenclature (as demonstrated here) for bronchial subdivisions as far as the 6th generation. For simplification on this illustration, only some bronchial subdivisions are labeled as far as the 5th or 6th generation. Segmental bronchi (B) are numbered from 1 to 10 in each lung, corresponding to pulmonary segments. In the left lung, B^1 and B^2 are combined as are B^7 and B^8. Subsegmental, or 4th order, bronchi are indicated by the addition of lowercase letters a, b, or c when an additional branch is present. Fifth order bronchi are designated by Roman numerals i (anterior) or ii (posterior) and 6th order bronchi by Greek letters α or β. Several texts use alternate numbers (as proposed by Boyden) for segmental bronchi.

Variations of the standard bronchial pattern shown here are common, especially in peripheral airways.

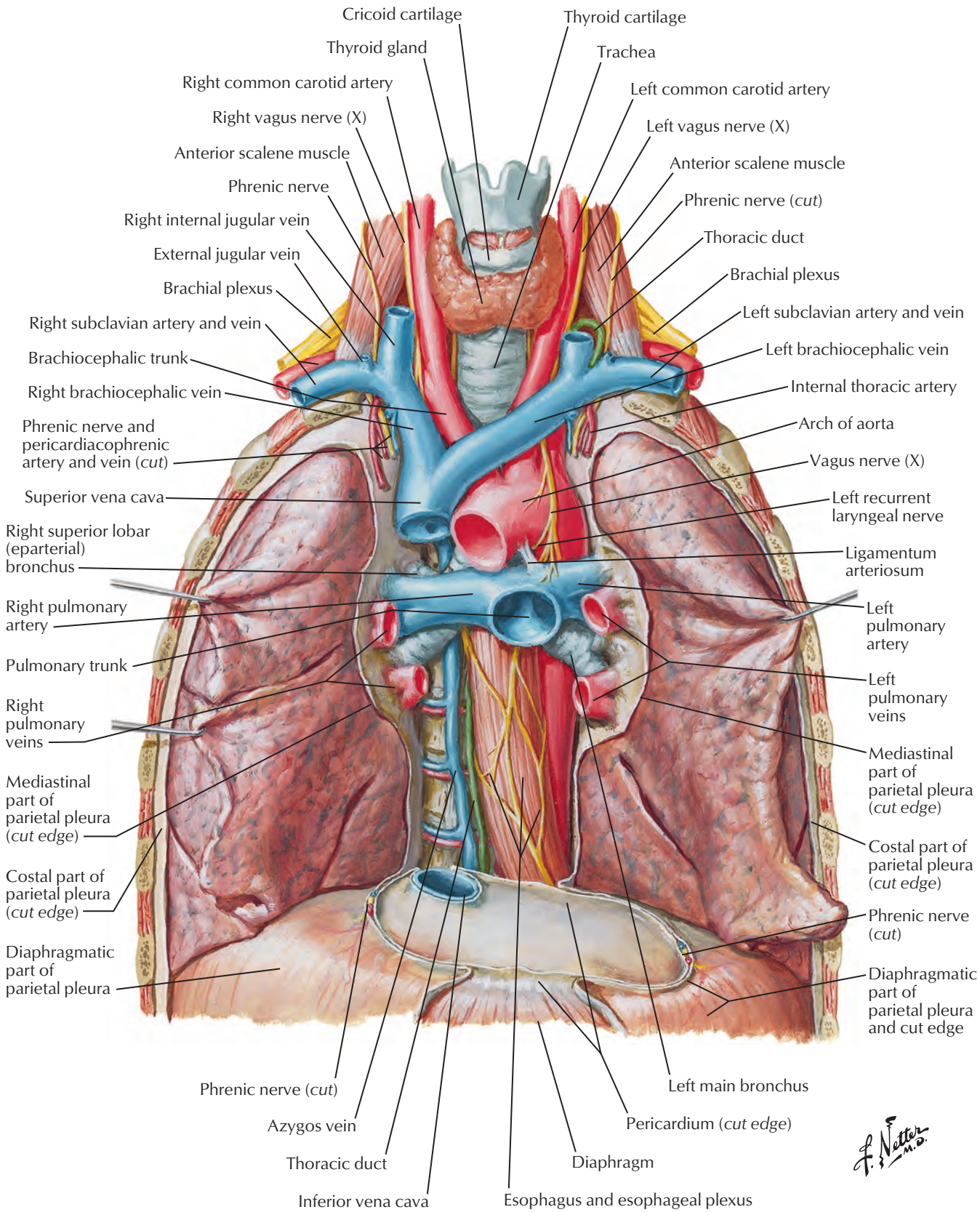


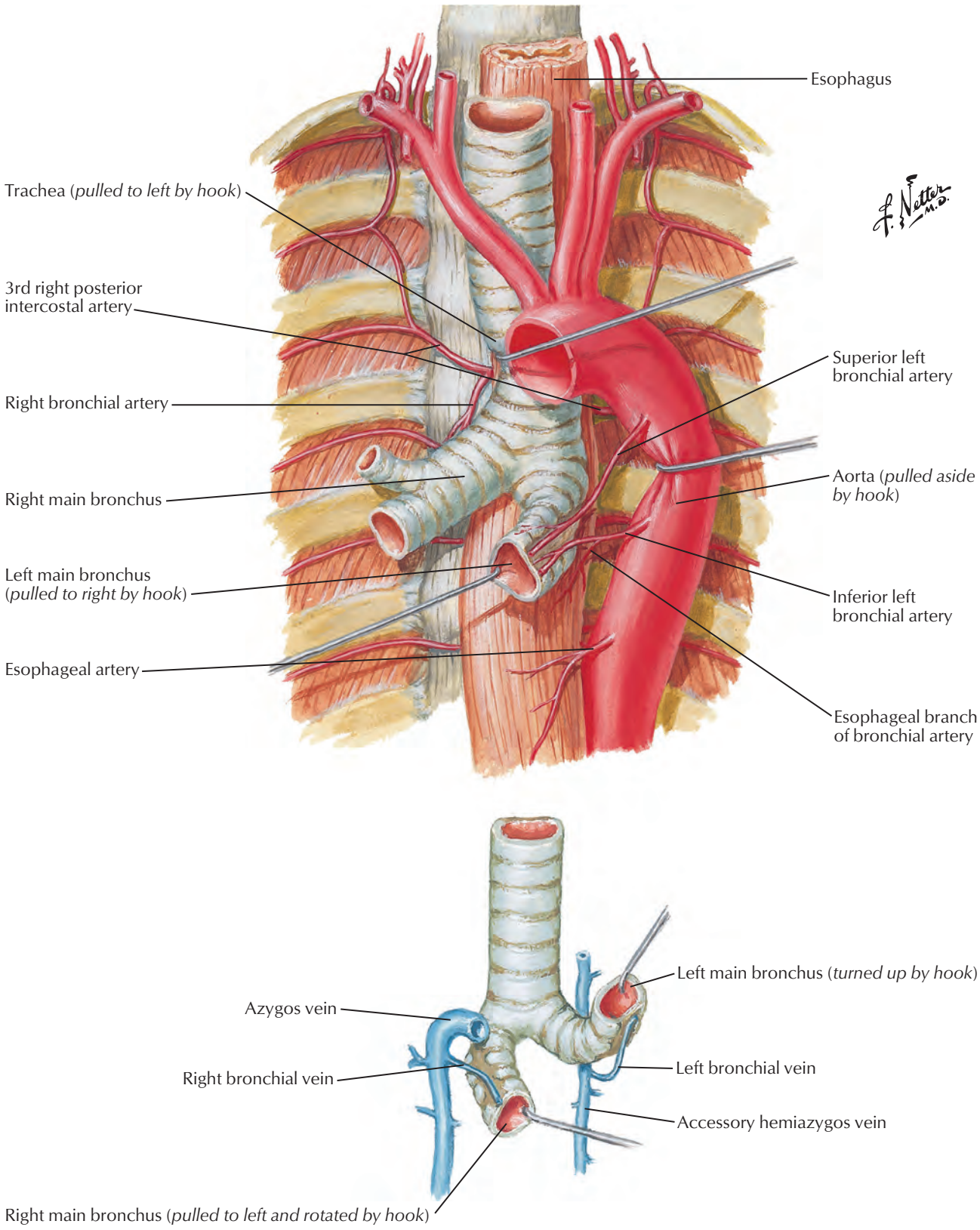
Subdivisions of intrapulmonary airways

Structure of intrapulmonary airways

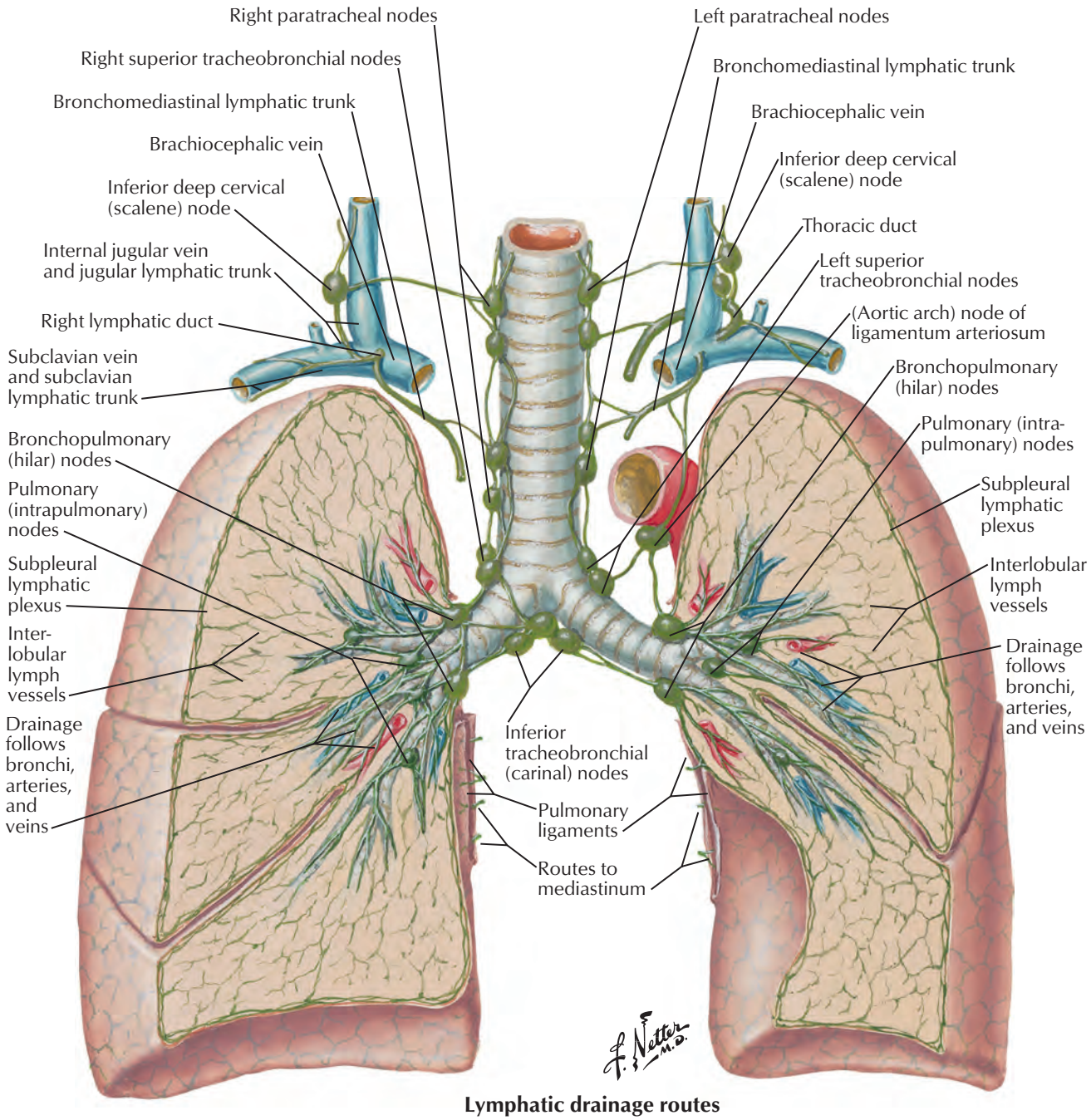


Pulmonary arteries and their branches distribute segmentally with the bronchi. Pulmonary veins and their tributaries drain intersegmentally.


Cricoid cartilage
Thyroid cartilage
Thyroid gland
Trachea
Right common carotid artery
Left common carotid artery
Right vagus nerve (X)
Left vagus nerve (X)
Anterior scalene muscle
Anterior scalene muscle
Phrenic nerve
Phrenic nerve (cut)
Right internal jugular vein
Thoracic duct
External jugular vein
Brachial plexus
Brachial plexus
Left subclavian artery and vein
Right subclavian artery and vein
Left brachiocephalic vein
Brachiocephalic trunk
Internal thoracic artery
Right brachiocephalic vein
Arch of aorta
Phrenic nerve and pericardiacophrenic artery and vein (cut)
Vagus nerve (X)
Superior vena cava
Left recurrent laryngeal nerve
Right superior lobar (eparterial) bronchus
Ligamentum arteriosum
Right pulmonary artery
Left pulmonary artery
Pulmonary trunk
Left pulmonary veins
Right pulmonary veins
Mediastinal part of parietal pleura (cut edge)
Mediastinal part of parietal pleura (cut edge)
Costal part of parietal pleura (cut edge)
Costal part of parietal pleura (cut edge)
Phrenic nerve (cut)
Diaphragmatic part of parietal pleura
Diaphragmatic part of parietal pleura and cut edge
Phrenic nerve (cut)
Left main bronchus
Azygos vein
Pericardium (cut edge)
Thoracic duct
Diaphragm
Inferior vena cava
Esophagus and esophageal plexus


Esophagus
Trachea (*pulled to left by hook*)
3rd right posterior intercostal artery
Right bronchial artery
Right main bronchus
Left main bronchus (*pulled to right by hook*)
Esophageal artery
Superior left bronchial artery
Aorta (*pulled aside by hook*)
Inferior left bronchial artery
Esophageal branch of bronchial artery
Left main bronchus (*turned up by hook*)
Azygos vein
Right bronchial vein
Left bronchial vein
Accessory hemiazygos vein
Right main bronchus (*pulled to left and rotated by hook*)

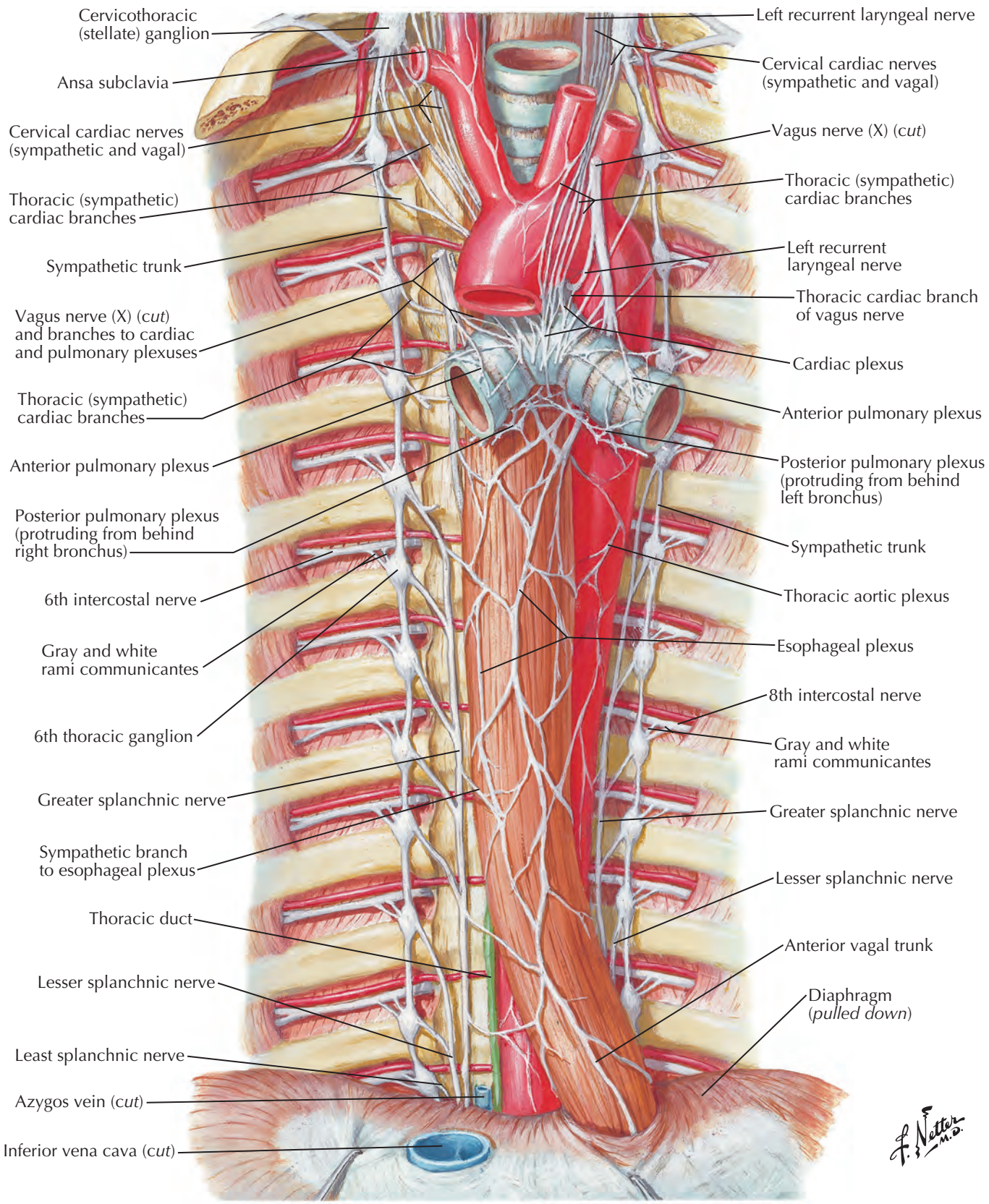
See also **Plates 74, 235**

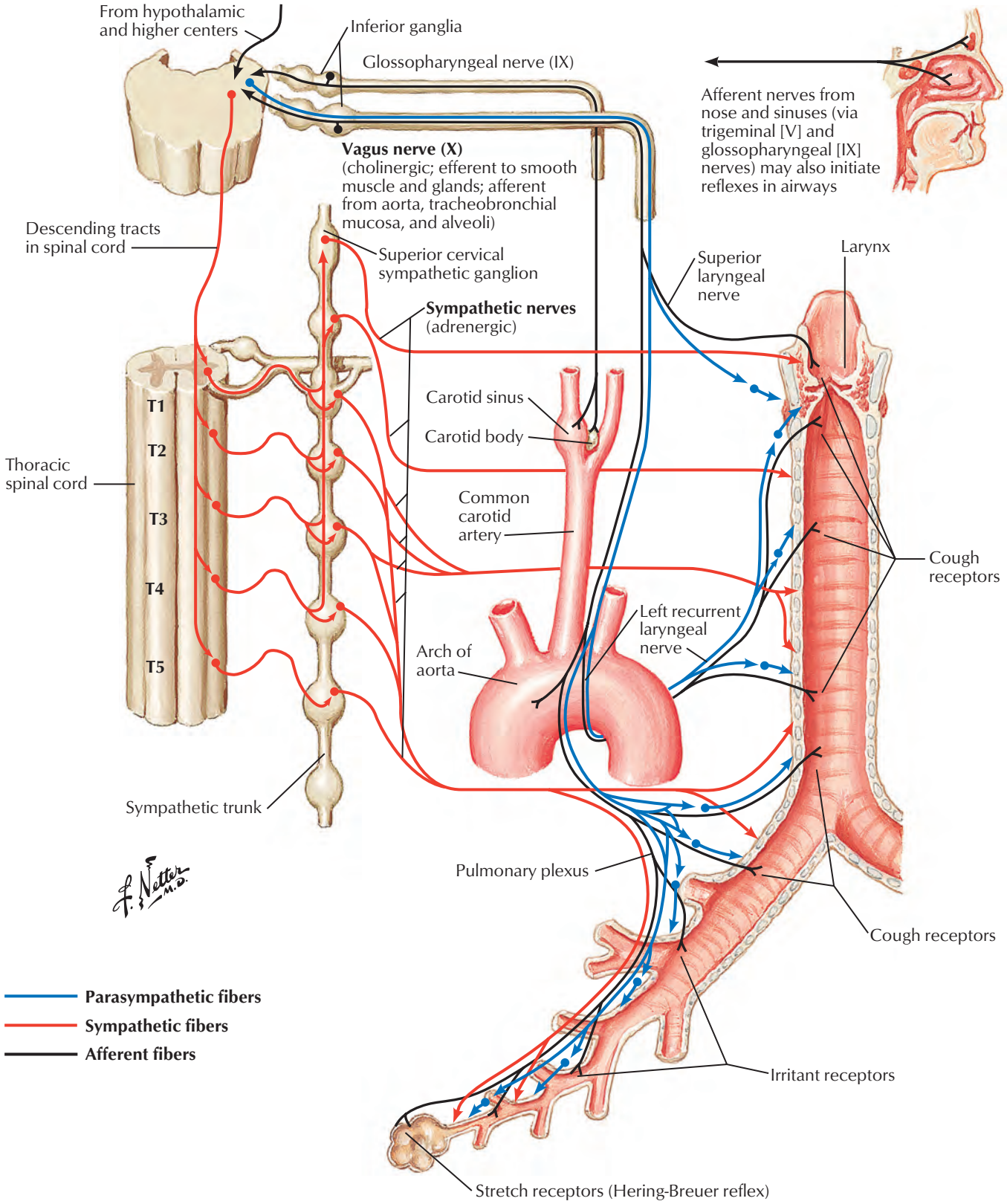


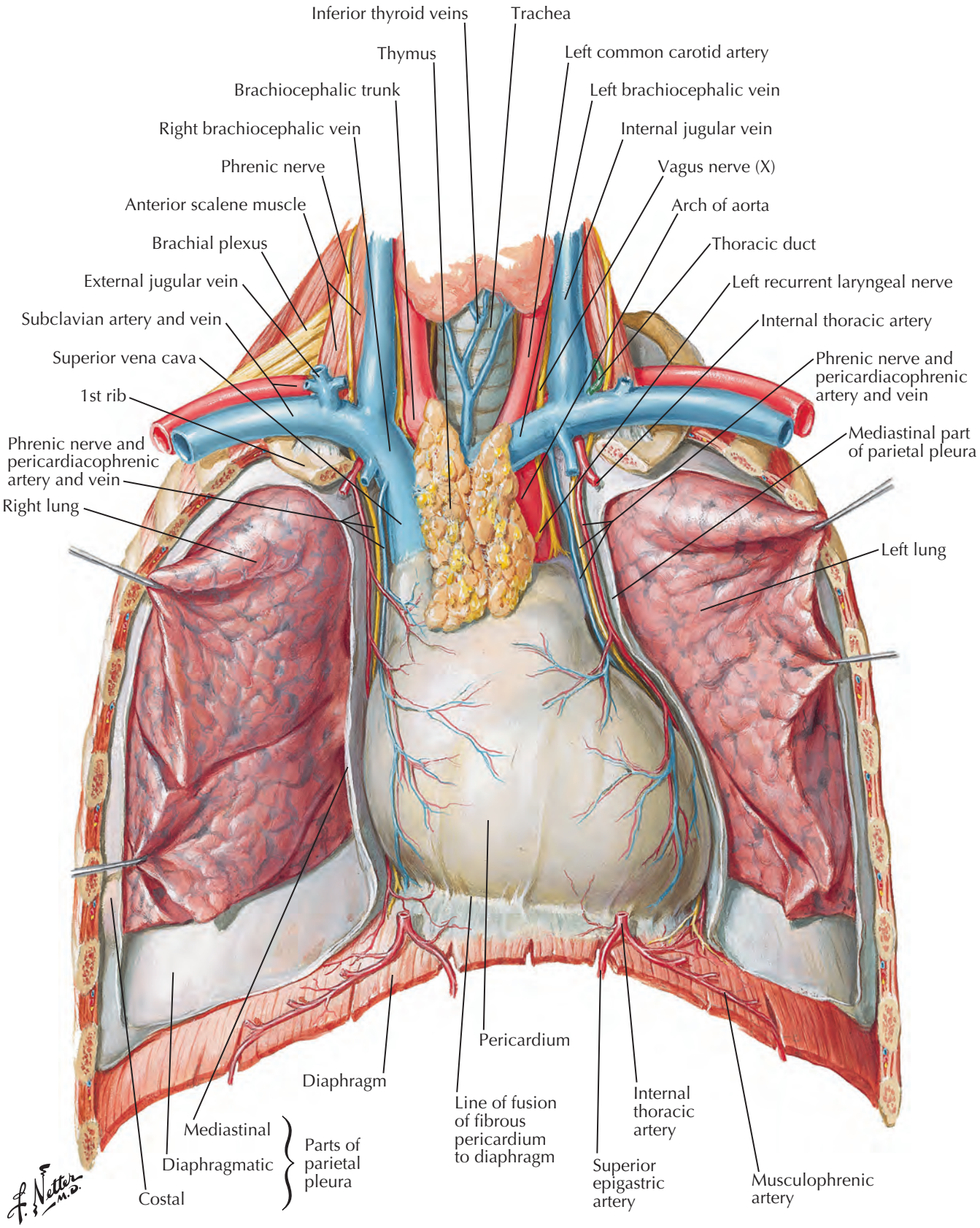
Lymphatic drainage routes

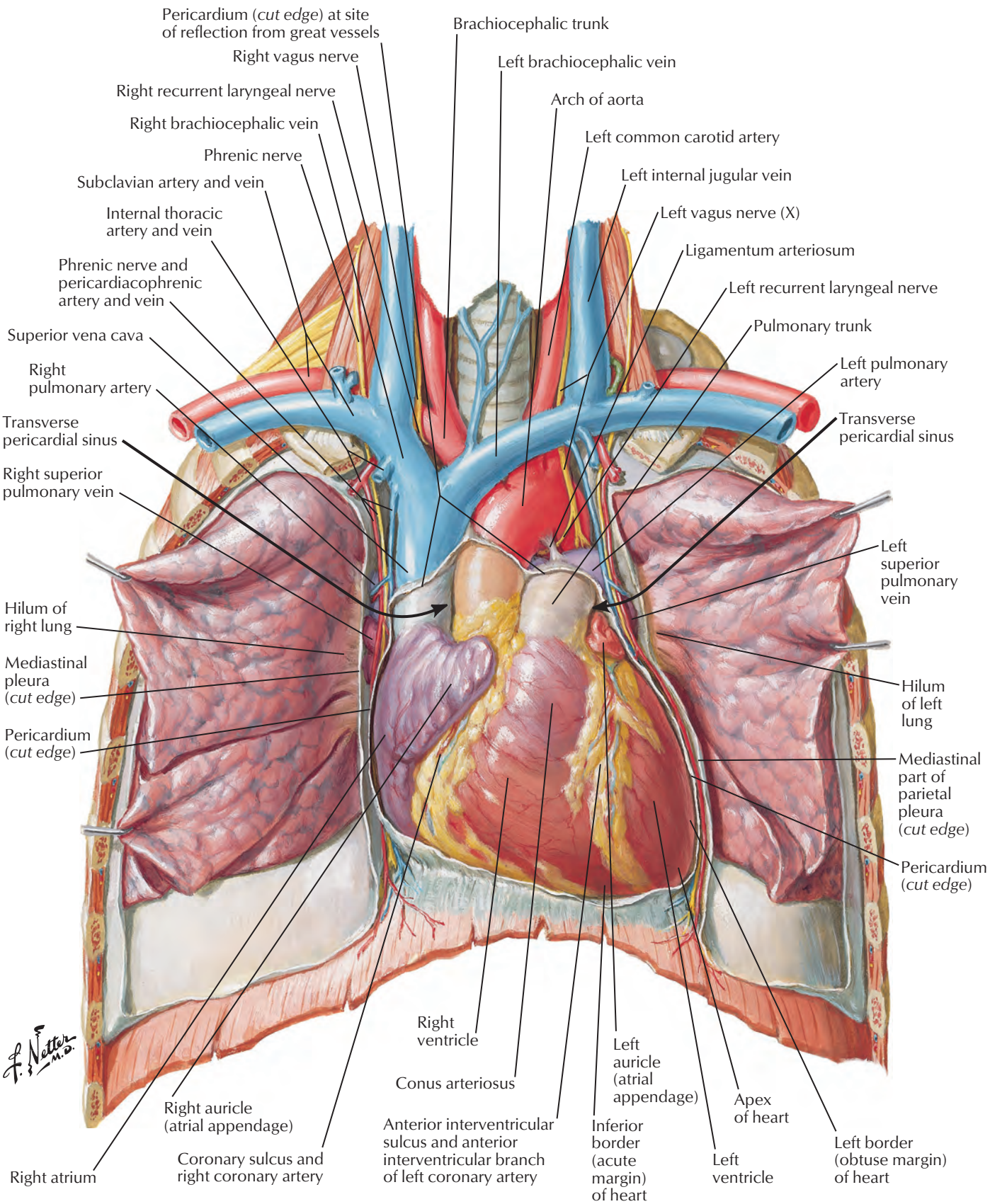
Right lung: All lobes drain to pulmonary and bronchopulmonary (hilar) nodes, then to inferior tracheobronchial (carinal) nodes, right superior tracheobronchial nodes, and right paratracheal nodes on the way to the brachiocephalic vein via the bronchomediastinal lymphatic trunk and/or inferior deep cervical (scalene) node.

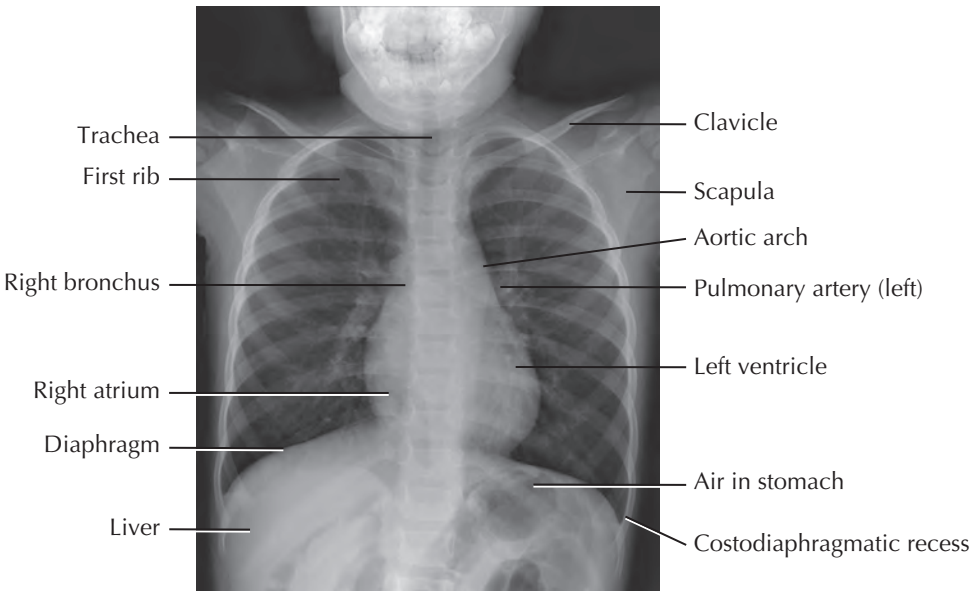
Left lung: The superior lobe drains to pulmonary and bronchopulmonary (hilar) nodes, inferior tracheobronchial (carinal) nodes, left superior tracheobronchial nodes, left paratracheal nodes and/or (aortic arch) node of ligamentum arteriosum, then to the brachiocephalic vein via the left bronchomediastinal trunk and thoracic duct. The left inferior lobe also drains to the pulmonary and bronchopulmonary (hilar) nodes and to inferior tracheobronchial (carinal) nodes, but then mostly to right superior tracheobronchial nodes, where it follows the same route as lymph from the right lung.

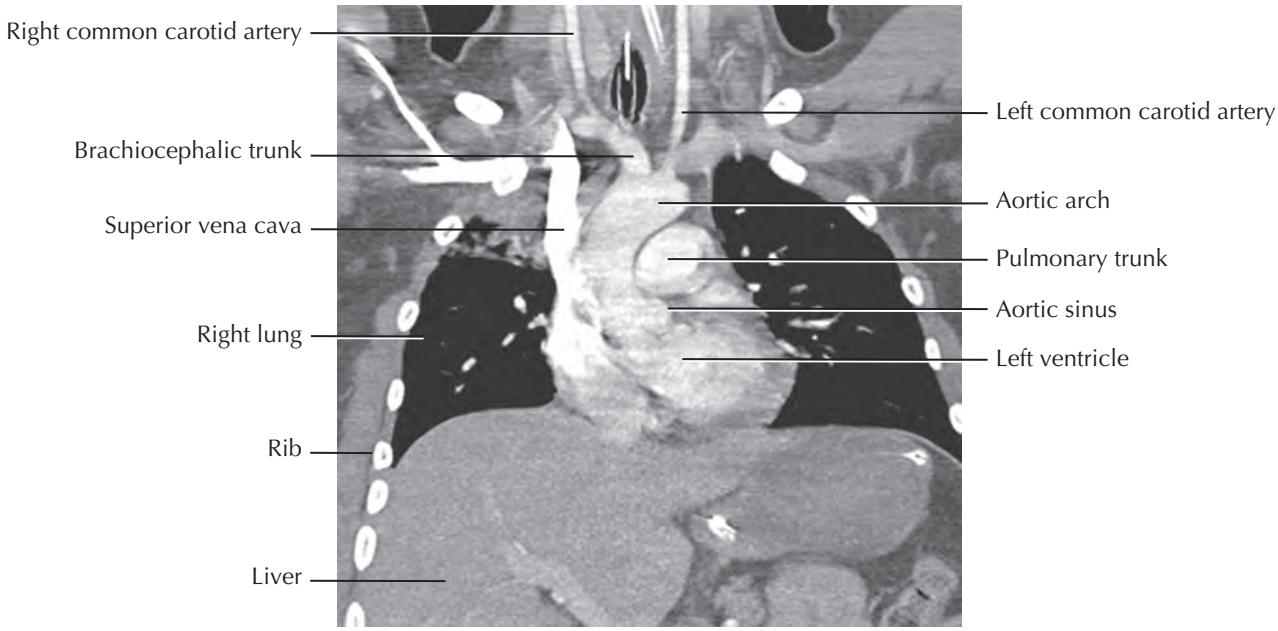

Cervicothoracic (stellate) ganglion
Ansa subclavia
Cervical cardiac nerves (sympathetic and vagal)
Thoracic (sympathetic) cardiac branches
Sympathetic trunk
Vagus nerve (X) (cut) and branches to cardiac and pulmonary plexuses
Thoracic (sympathetic) cardiac branches
Anterior pulmonary plexus
Posterior pulmonary plexus (protruding from behind right bronchus)
6th intercostal nerve
Gray and white rami communicantes
6th thoracic ganglion
Greater splanchnic nerve
Sympathetic branch to esophageal plexus
Thoracic duct
Lesser splanchnic nerve
Least splanchnic nerve
Azygos vein (cut)
Inferior vena cava (cut)
Left recurrent laryngeal nerve
Cervical cardiac nerves (sympathetic and vagal)
Vagus nerve (X) (cut)
Thoracic (sympathetic) cardiac branches
Left recurrent laryngeal nerve
Thoracic cardiac branch of vagus nerve
Cardiac plexus
Anterior pulmonary plexus
Posterior pulmonary plexus (protruding from behind left bronchus)
Sympathetic trunk
Thoracic aortic plexus
Esophageal plexus
8th intercostal nerve
Gray and white rami communicantes
Greater splanchnic nerve
Lesser splanchnic nerve
Anterior vagal trunk
Diaphragm (pulled down)


From hypothalamic and higher centers
Inferior ganglia
Glossopharyngeal nerve (IX)
Afferent nerves from nose and sinuses (via trigeminal [V] and glossopharyngeal [IX] nerves) may also initiate reflexes in airways
Vagus nerve (X)
(cholinergic; efferent to smooth muscle and glands; afferent from aorta, tracheobronchial mucosa, and alveoli)
Descending tracts in spinal cord
Superior cervical sympathetic ganglion
Superior laryngeal nerve
Larynx
Sympathetic nerves
(adrenergic)
T1
T2
T3
T4
T5
Thoracic spinal cord
Carotid sinus
Carotid body
Common carotid artery
Cough receptors
Left recurrent laryngeal nerve
Arch of aorta
Sympathetic trunk
Pulmonary plexus
Cough receptors
Parasympathetic fibers
Sympathetic fibers
Afferent fibers
Irritant receptors
Stretch receptors (Hering-Breuer reflex)

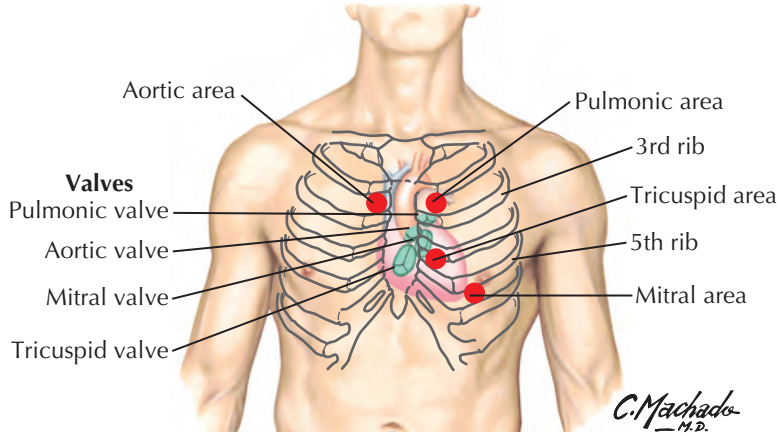

Inferior thyroid veins
Trachea
Thymus
Left common carotid artery
Brachiocephalic trunk
Left brachiocephalic vein
Right brachiocephalic vein
Internal jugular vein
Phrenic nerve
Vagus nerve (X)
Anterior scalene muscle
Arch of aorta
Brachial plexus
Thoracic duct
External jugular vein
Left recurrent laryngeal nerve
Subclavian artery and vein
Internal thoracic artery
Superior vena cava
Phrenic nerve and pericardiacophrenic artery and vein
1st rib
Mediastinal part of parietal pleura
Phrenic nerve and pericardiacophrenic artery and vein
Right lung
Left lung
Pericardium
Diaphragm
Line of fusion of fibrous pericardium to diaphragm
Internal thoracic artery
Mediastinal
Diaphragmatic
Parts of parietal pleura
Costal
Superior epigastric artery
Musculophrenic artery

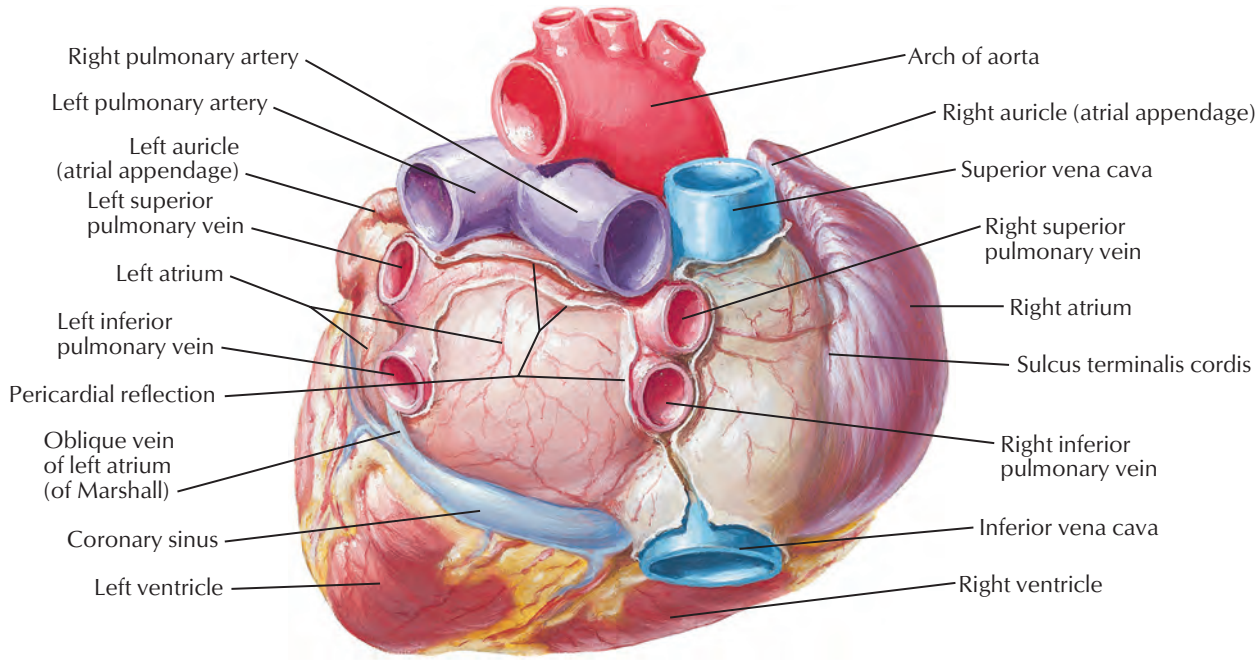

Pericardium (*cut edge*) at site of reflection from great vessels
Right vagus nerve
Right recurrent laryngeal nerve
Right brachiocephalic vein
Phrenic nerve
Subclavian artery and vein
Internal thoracic artery and vein
Phrenic nerve and pericardiacophrenic artery and vein
Superior vena cava
Right pulmonary artery
Transverse pericardial sinus
Right superior pulmonary vein
Hilum of right lung
Mediastinal pleura (*cut edge*)
Pericardium (*cut edge*)
Brachiocephalic trunk
Left brachiocephalic vein
Arch of aorta
Left common carotid artery
Left internal jugular vein
Left vagus nerve (X)
Ligamentum arteriosum
Left recurrent laryngeal nerve
Pulmonary trunk
Left pulmonary artery
Transverse pericardial sinus
Left superior pulmonary vein
Hilum of left lung
Mediastinal part of parietal pleura (*cut edge*)
Pericardium (*cut edge*)
Right ventricle
Conus arteriosus
Left auricle (atrial appendage)
Apex of heart
Right auricle (atrial appendage)
Anterior interventricular sulcus and anterior interventricular branch of left coronary artery
Inferior border (acute margin) of heart
Left ventricle
Left border (obtuse margin) of heart
Right atrium
Coronary sulcus and right coronary artery



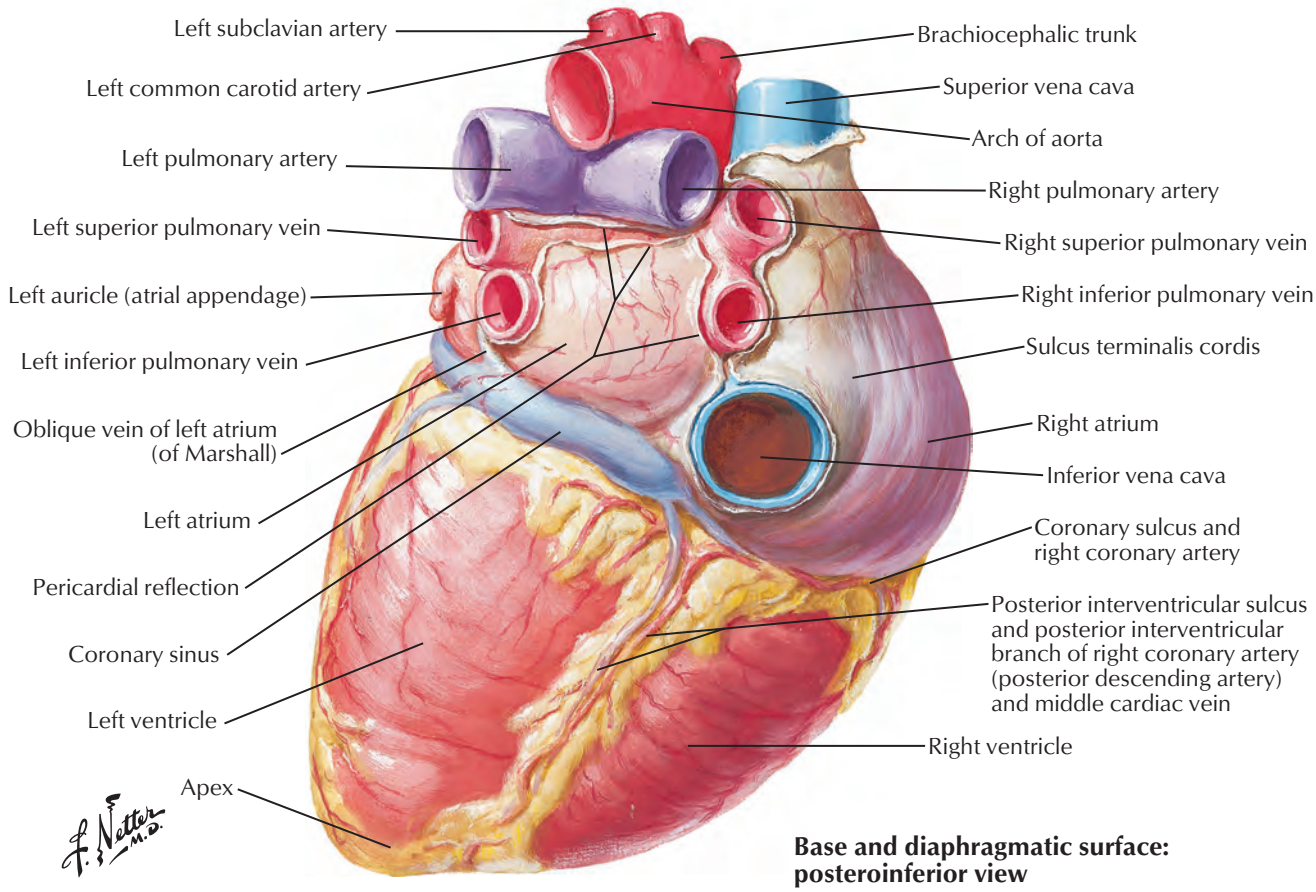


Precordial areas of auscultation

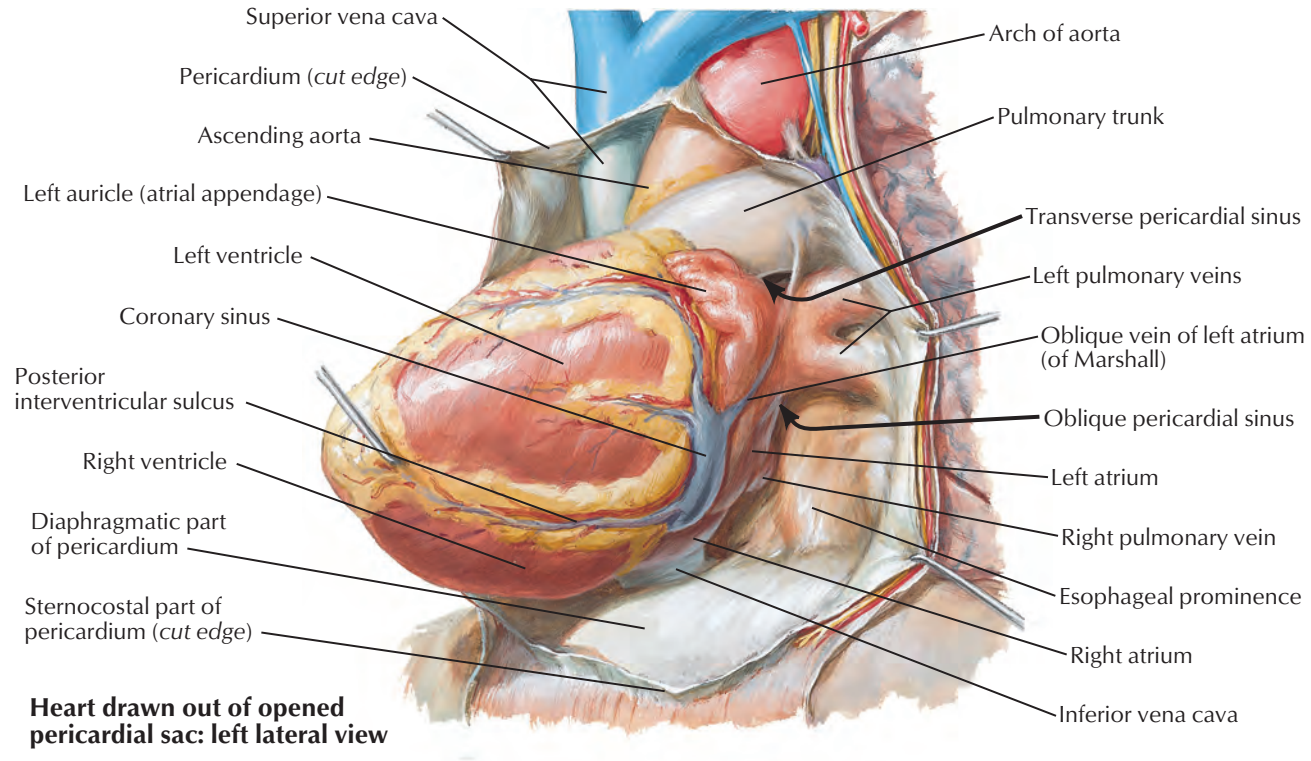




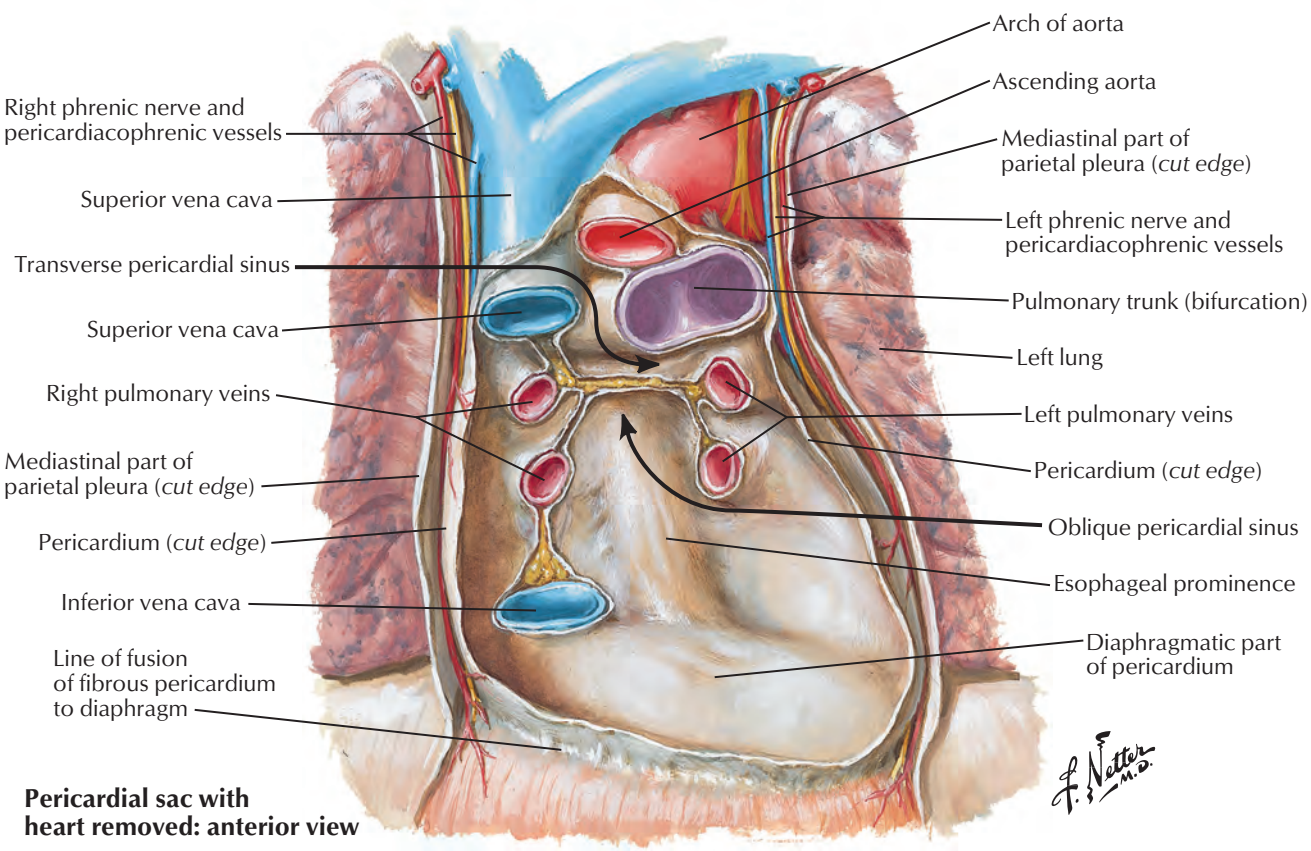
Base of heart: posterior view



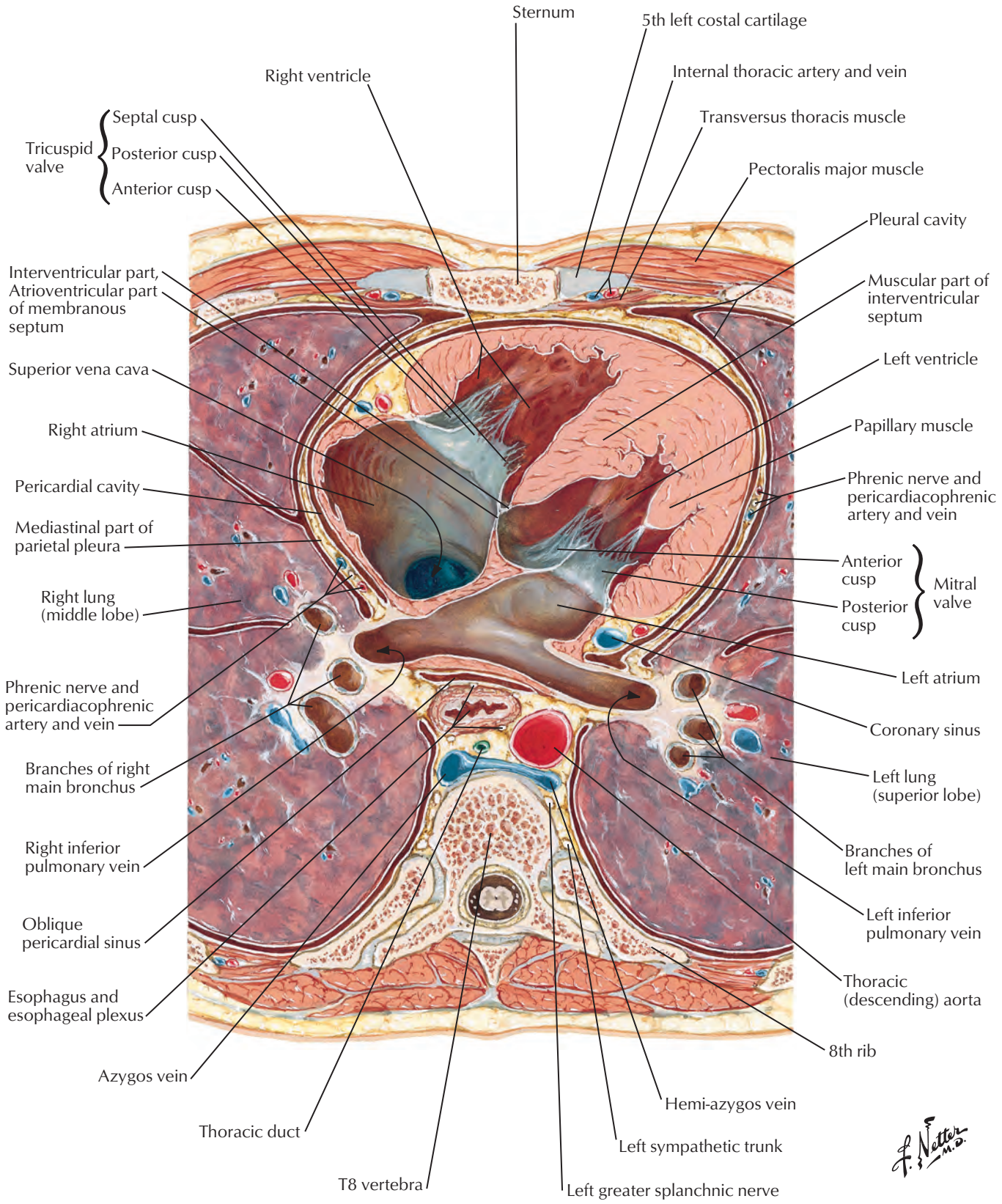
Base and diaphragmatic surface: posteroinferior view

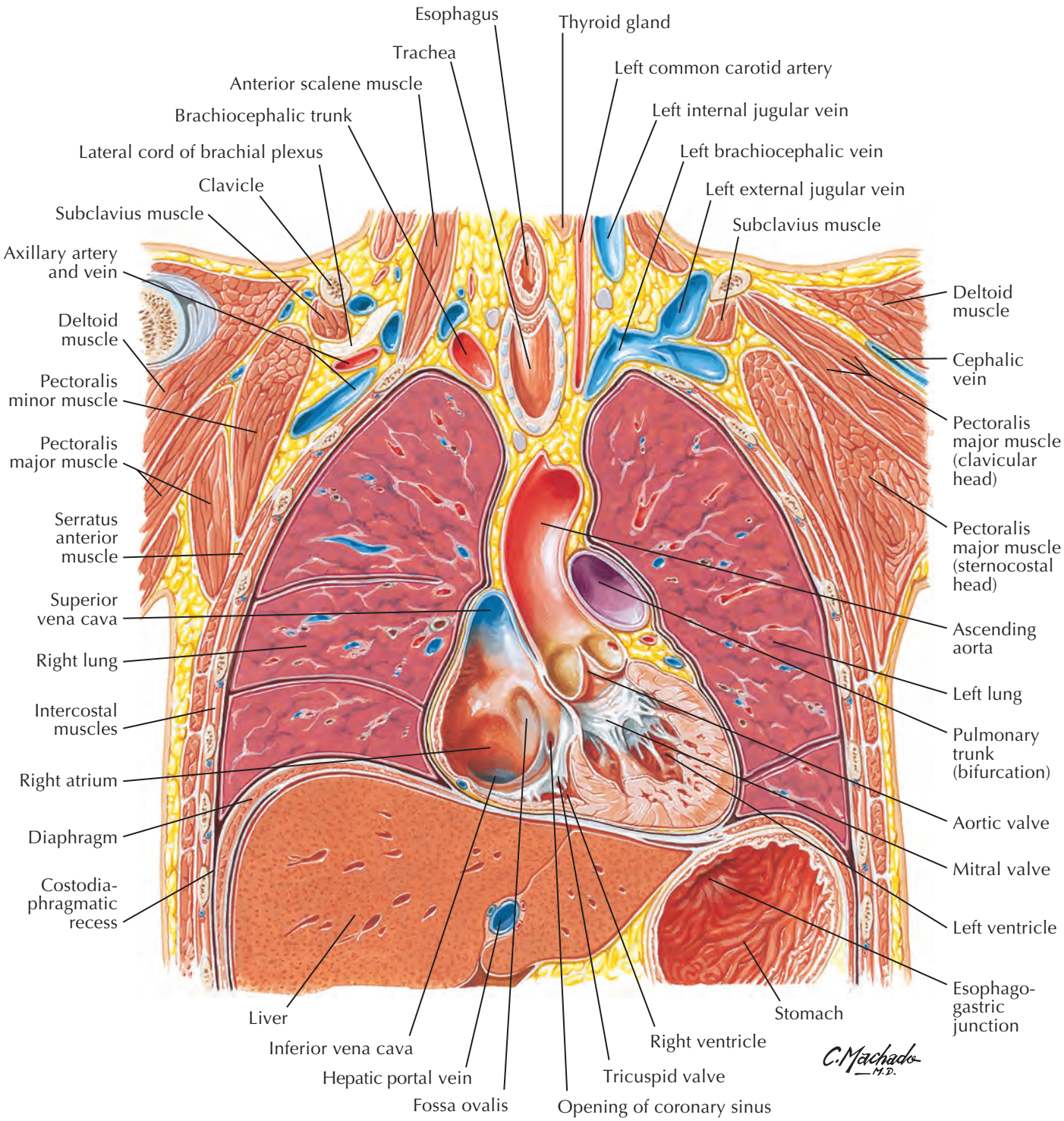


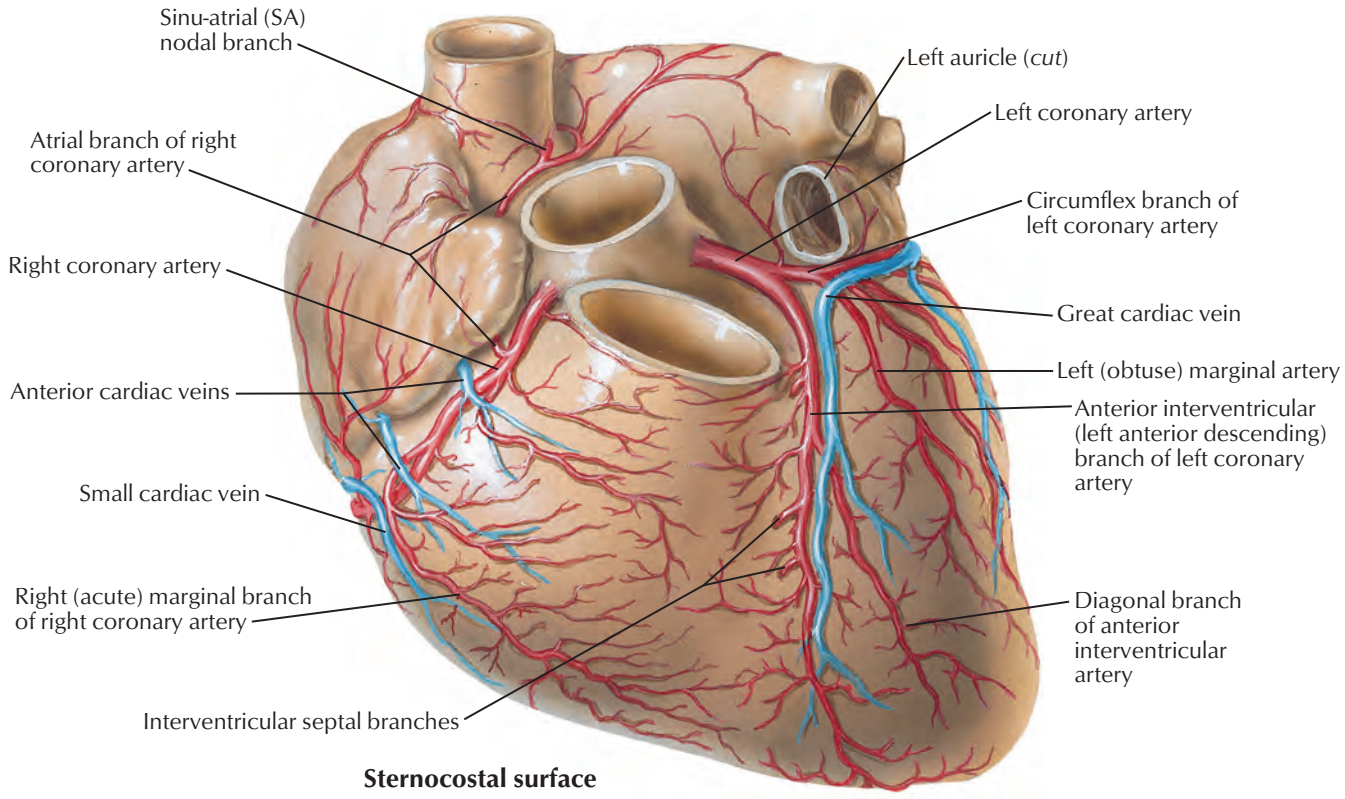
Heart drawn out of opened pericardial sac: left lateral view



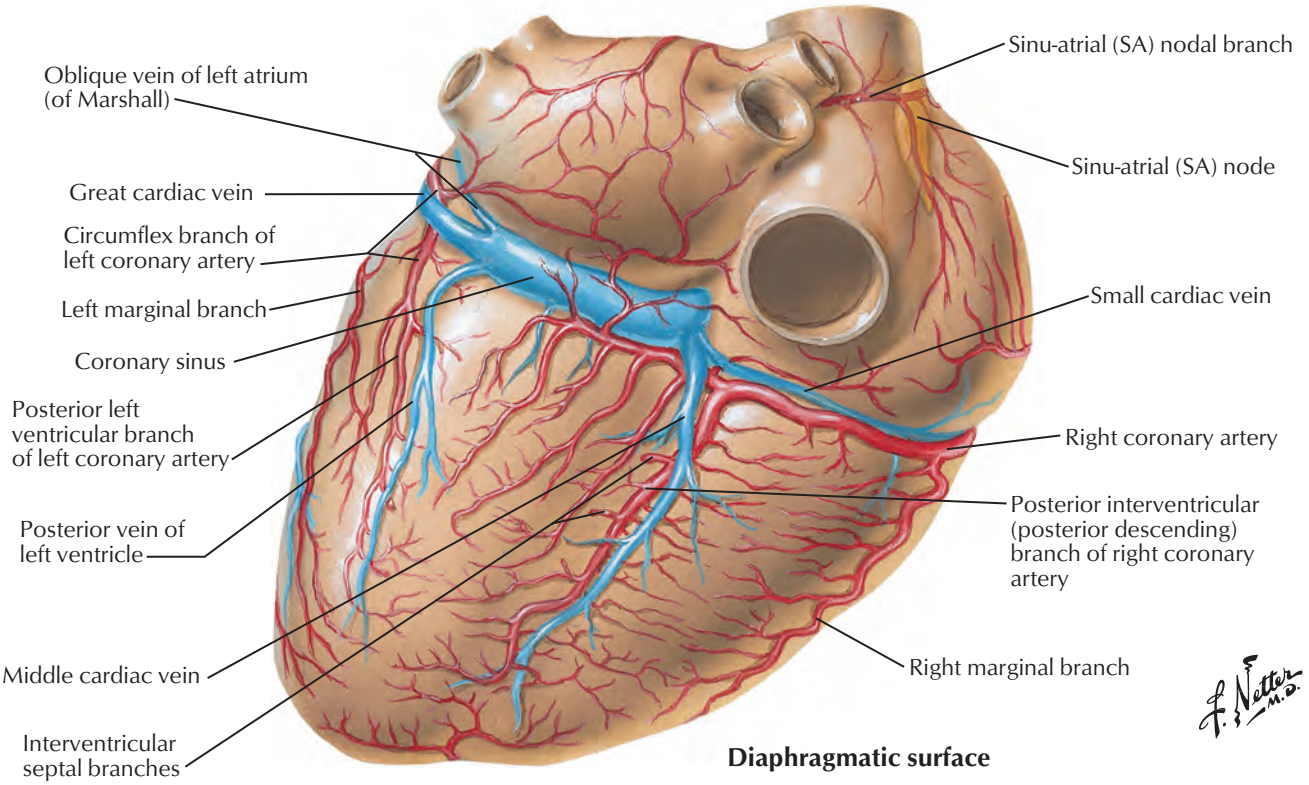
Pericardial sac with heart removed: anterior view


Sternum
5th left costal cartilage
Right ventricle
Internal thoracic artery and vein
Transversus thoracis muscle
Tricuspid valve
Septal cusp
Posterior cusp
Anterior cusp
Pectoralis major muscle
Pleural cavity
Interventricular part, Atrioventricular part of membranous septum
Muscular part of interventricular septum
Superior vena cava
Left ventricle
Right atrium
Papillary muscle
Pericardial cavity
Phrenic nerve and pericardiacophrenic artery and vein
Mediastinal part of parietal pleura
Anterior cusp
Posterior cusp
Mitral valve
Right lung (middle lobe)
Left atrium
Phrenic nerve and pericardiacophrenic artery and vein
Coronary sinus
Branches of right main bronchus
Left lung (superior lobe)
Right inferior pulmonary vein
Branches of left main bronchus
Oblique pericardial sinus
Left inferior pulmonary vein
Thoracic (descending) aorta
Esophagus and esophageal plexus
8th rib
Azygos vein
Hemi-azygos vein
Thoracic duct
Left sympathetic trunk
T8 vertebra
Left greater splanchnic nerve

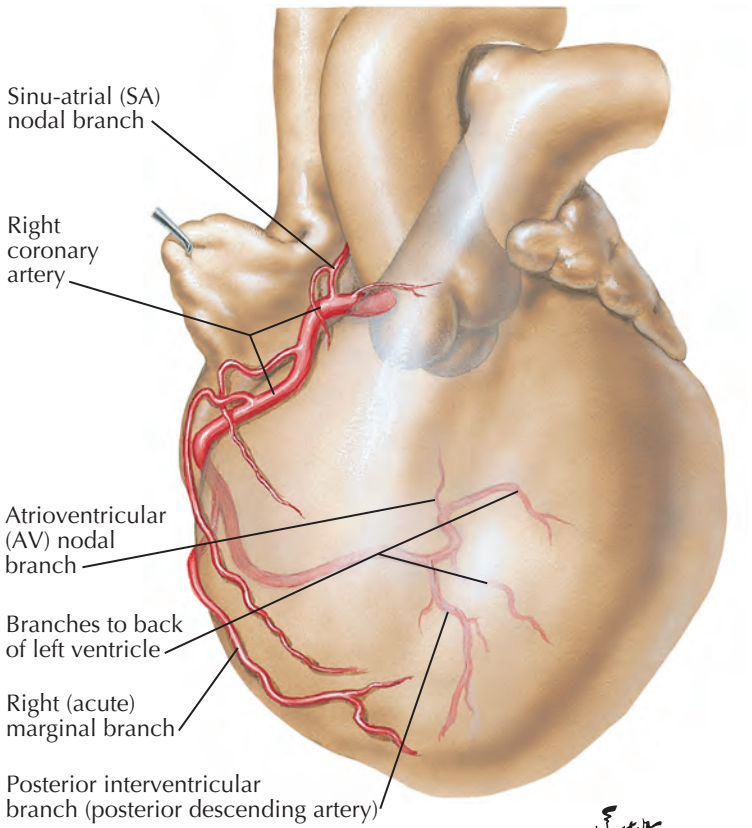

Esophagus
Thyroid gland
Trachea
Left common carotid artery
Anterior scalene muscle
Left internal jugular vein
Brachiocephalic trunk
Left brachiocephalic vein
Lateral cord of brachial plexus
Left external jugular vein
Clavicle
Subclavius muscle
Subclavius muscle
Axillary artery and vein
Deltoid muscle
Deltoid muscle
Cephalic vein
Pectoralis minor muscle
Pectoralis major muscle (clavicular head)
Pectoralis major muscle
Pectoralis major muscle (sternocostal head)
Serratus anterior muscle
Ascending aorta
Superior vena cava
Left lung
Right lung
Pulmonary trunk (bifurcation)
Intercostal muscles
Aortic valve
Right atrium
Mitral valve
Diaphragm
Left ventricle
Costodiaphragmatic recess
Esophagogastric junction
Liver
Stomach
Inferior vena cava
Right ventricle
Hepatic portal vein
Tricuspid valve
Fossa ovalis
Opening of coronary sinus
C. Machado M.D.

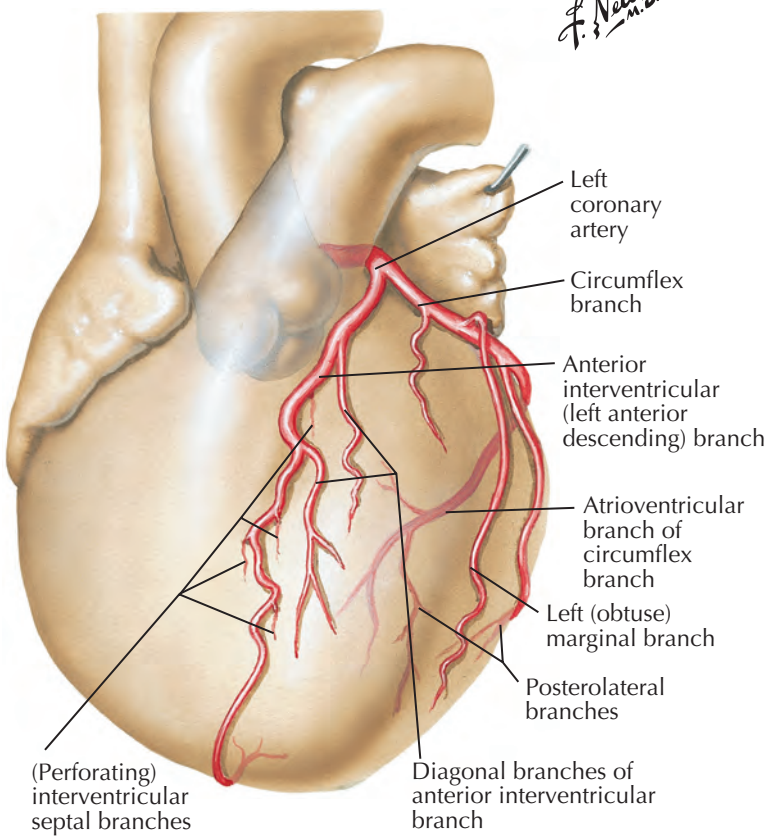


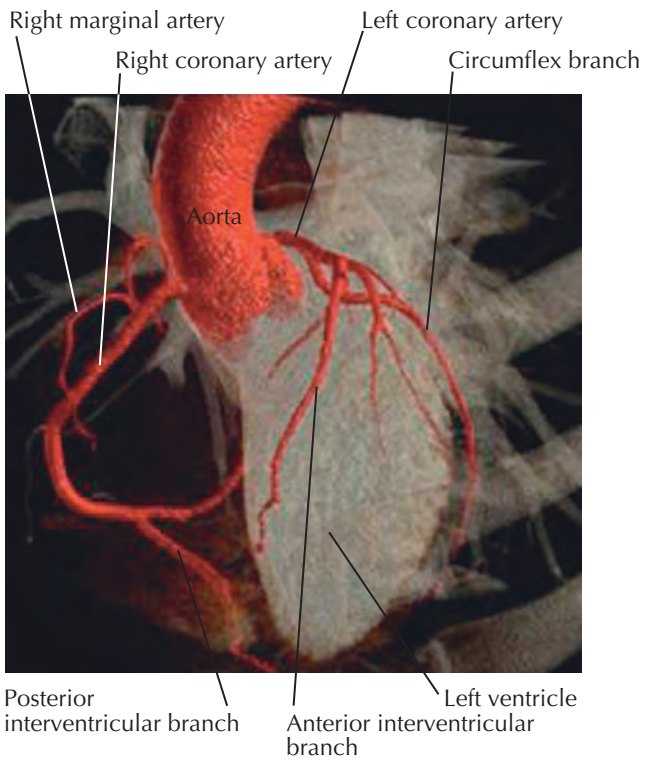
Sternocostal surface



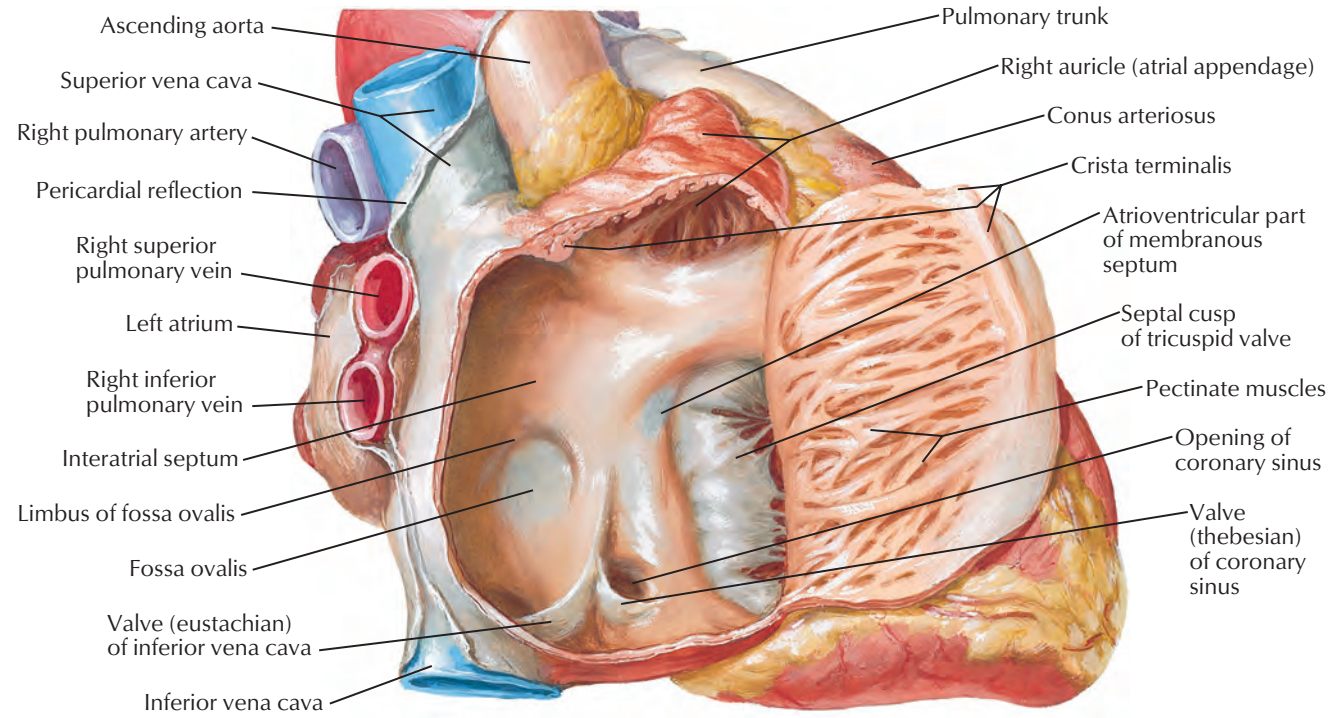
Diaphragmatic surface


Sinu-atrial (SA) nodal branch
Right coronary artery
Atrioventricular (AV) nodal branch
Branches to back of left ventricle
Right (acute) marginal branch
Posterior interventricular branch (posterior descending artery)

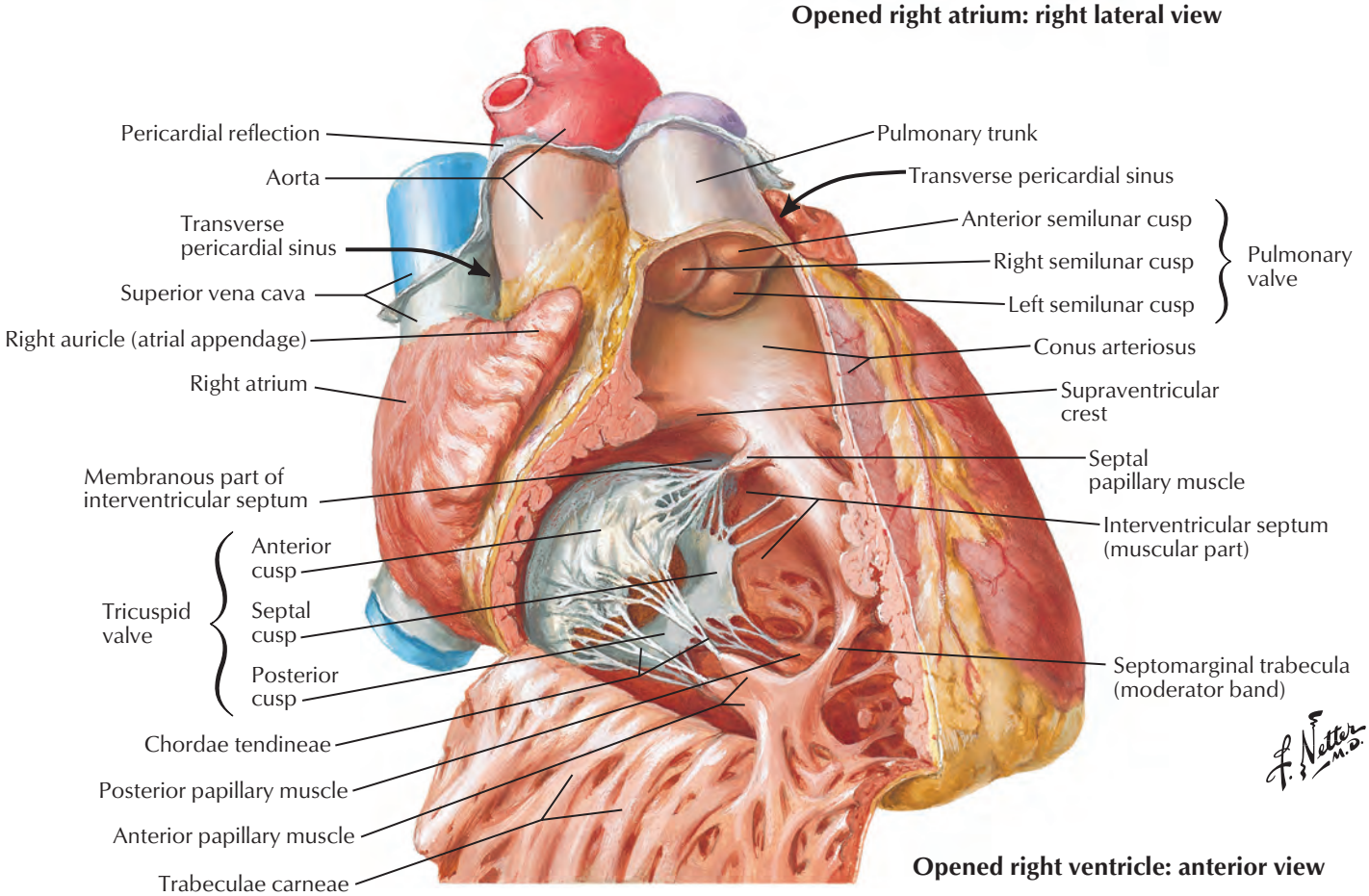

Left coronary artery
Circumflex branch
Anterior interventricular (left anterior descending) branch
Atrioventricular branch of circumflex branch
Left (obtuse) marginal branch
Posterolateral branches
(Perforating) interventricular septal branches
Diagonal branches of anterior interventricular branch


Right marginal artery
Right coronary artery
Left coronary artery
Circumflex branch
Aorta
Posterior interventricular branch
Anterior interventricular branch
Left ventricle

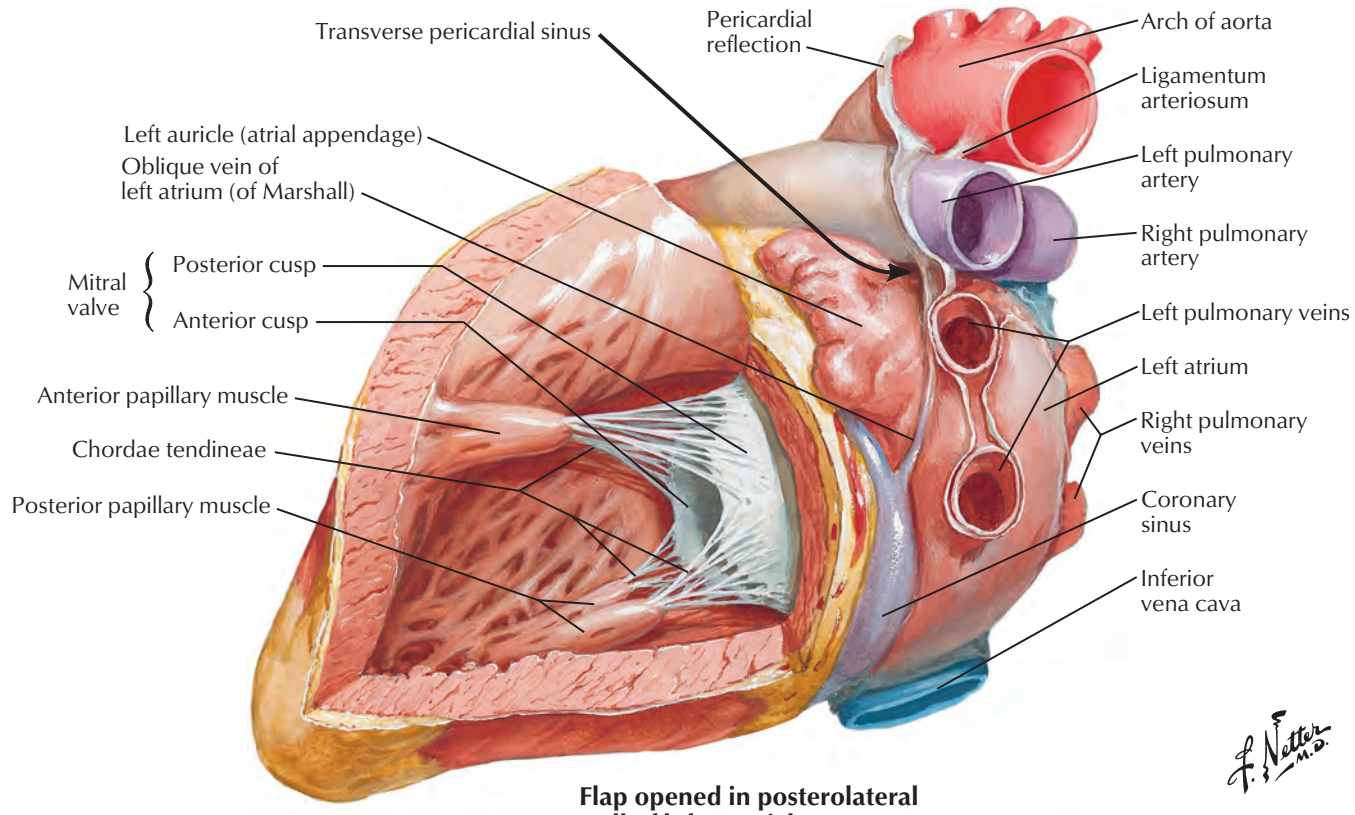
Right coronary artery
Left coronary artery
Left auricle
Aorta
Anterior interventricular branch
Left ventricle
Circumflex branch



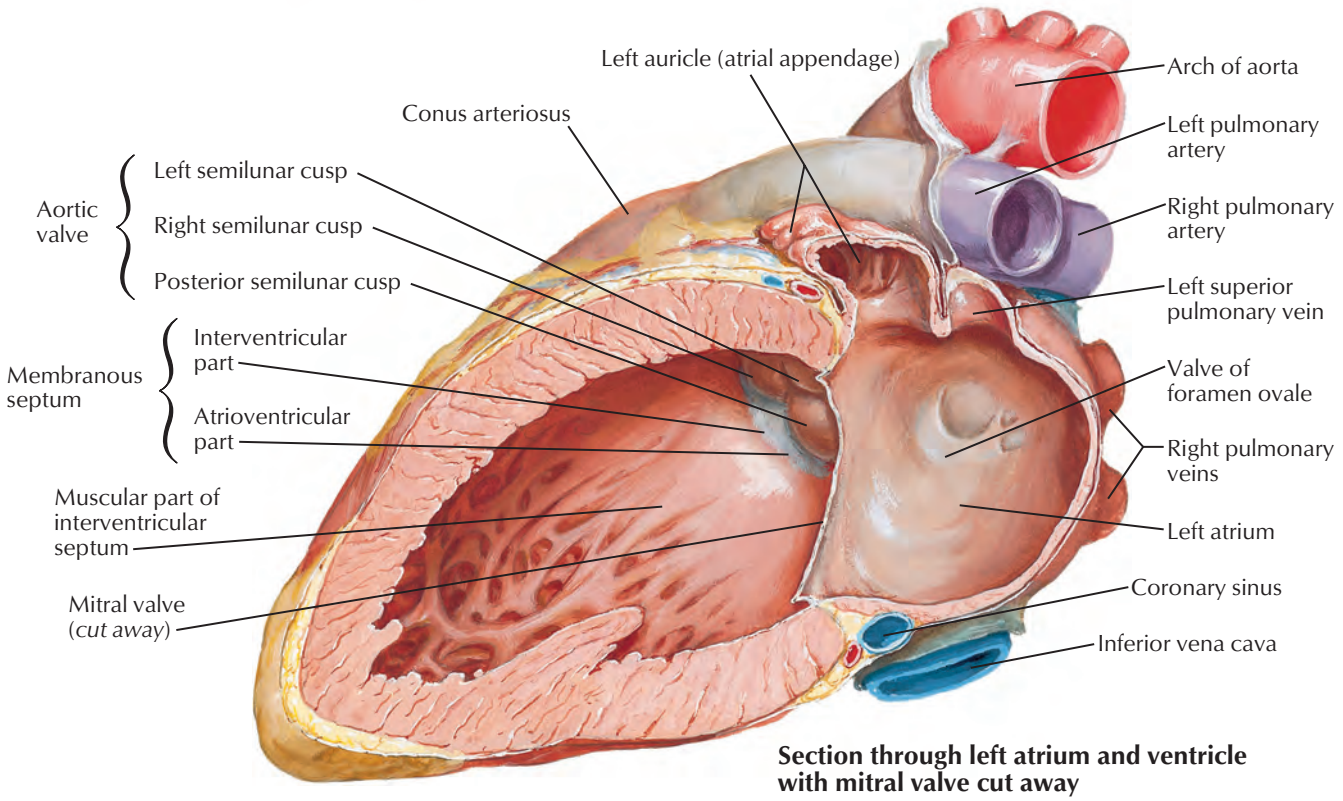
Opened right atrium: right lateral view



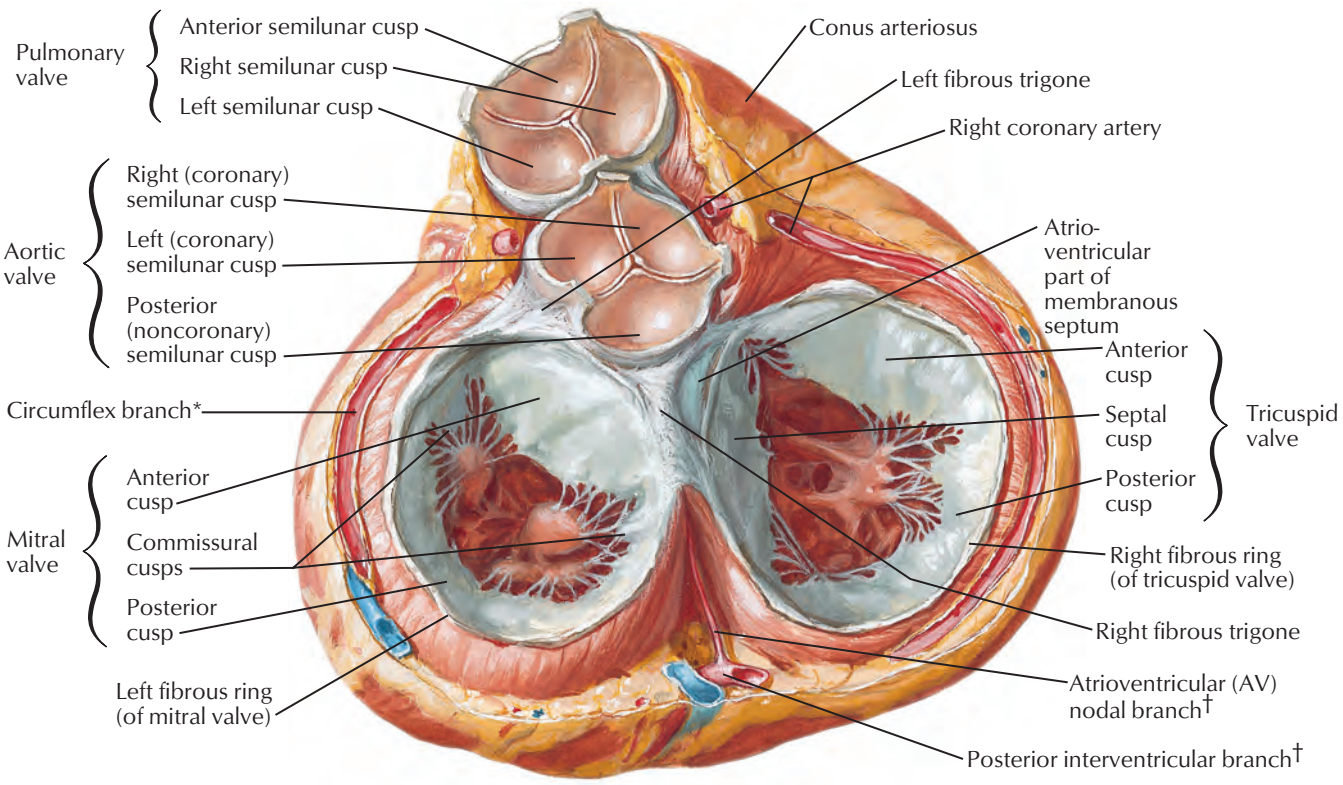
Opened right ventricle: anterior view



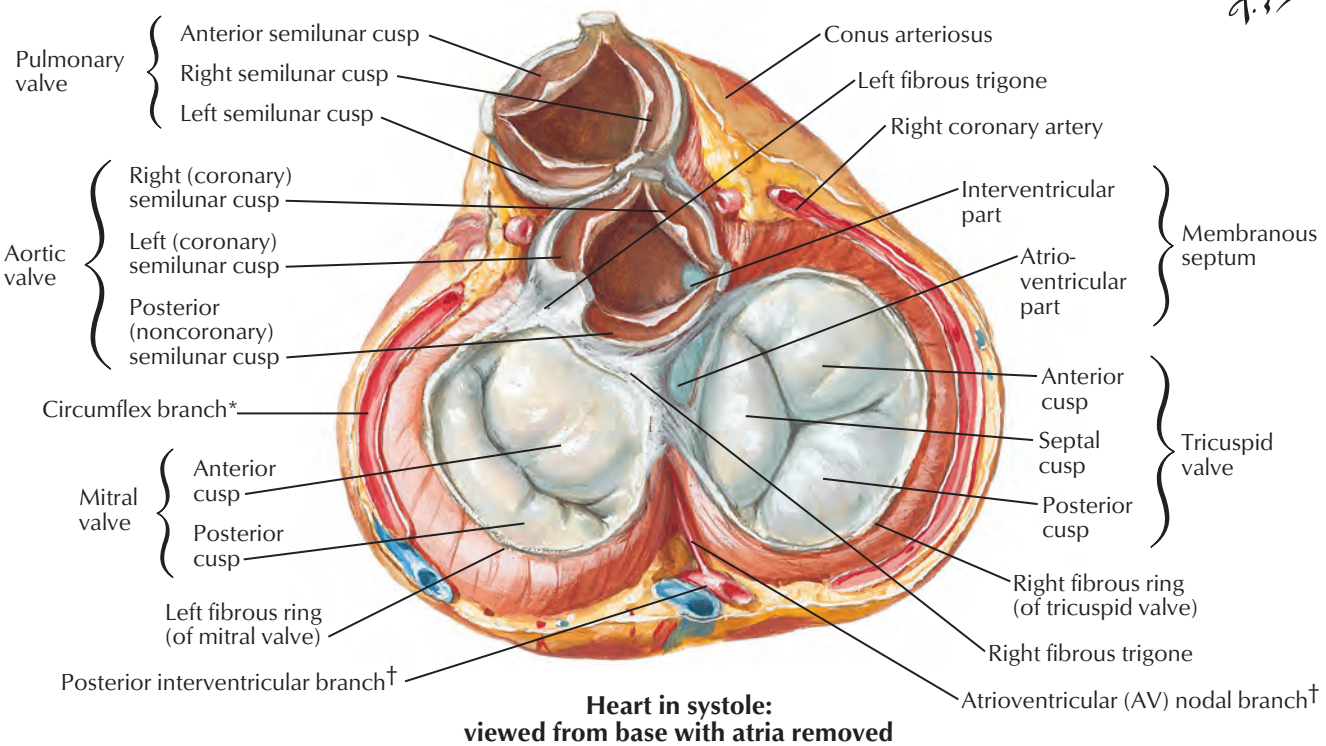
Flap opened in posterolateral wall of left ventricle



Section through left atrium and ventricle with mitral valve cut away

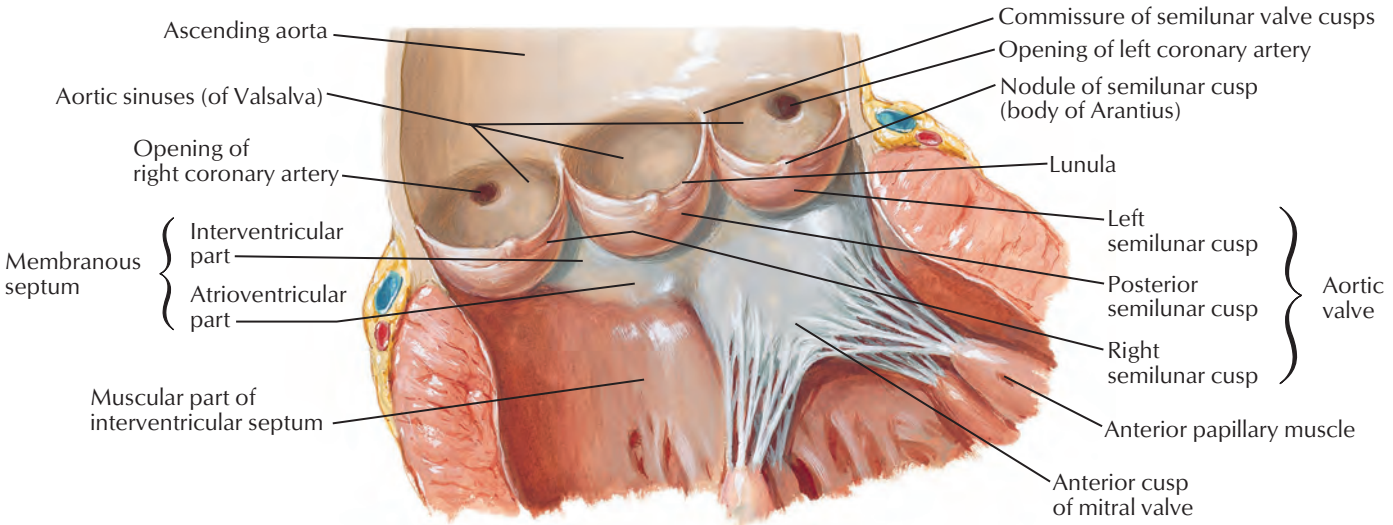


Heart in diastole:
viewed from base with atria removed

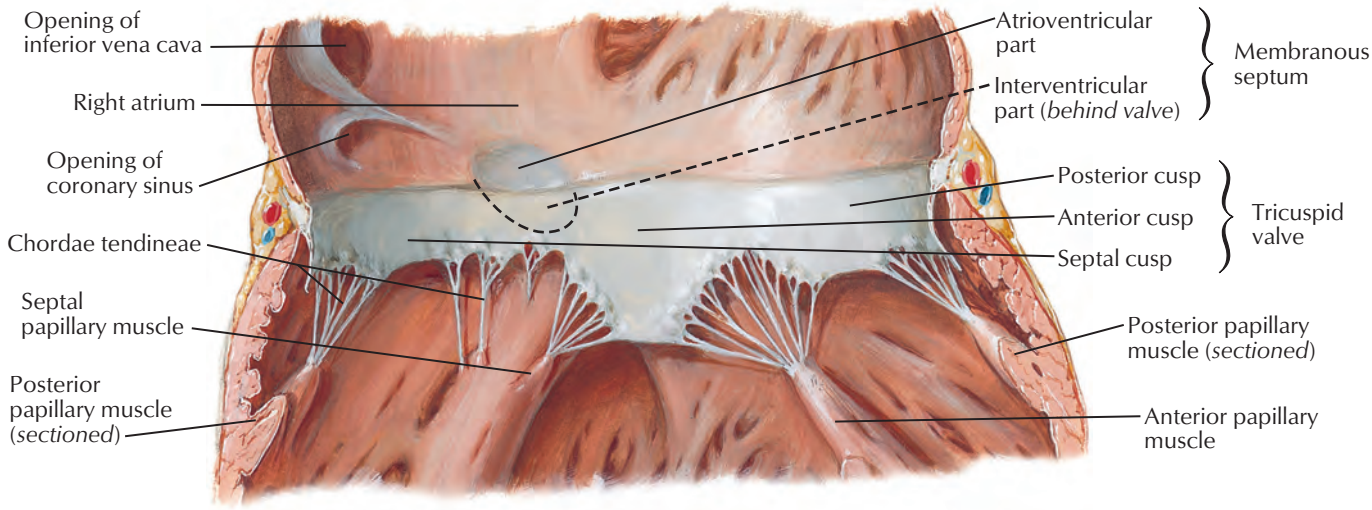


Heart in systole:
viewed from base with atria removed

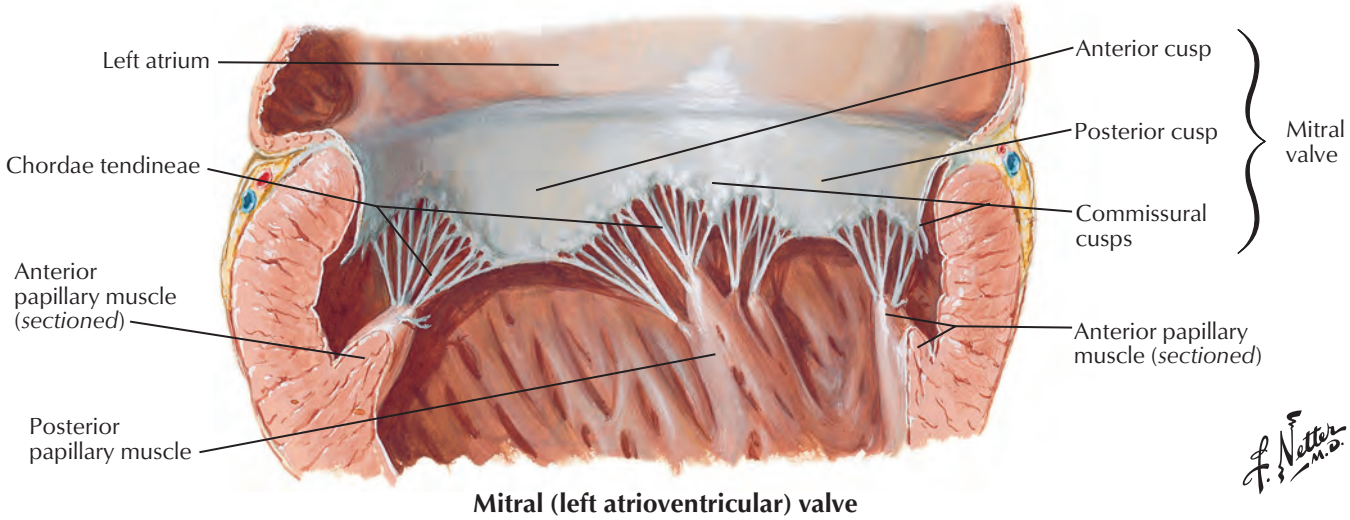
*Of left coronary artery
†Of right coronary artery



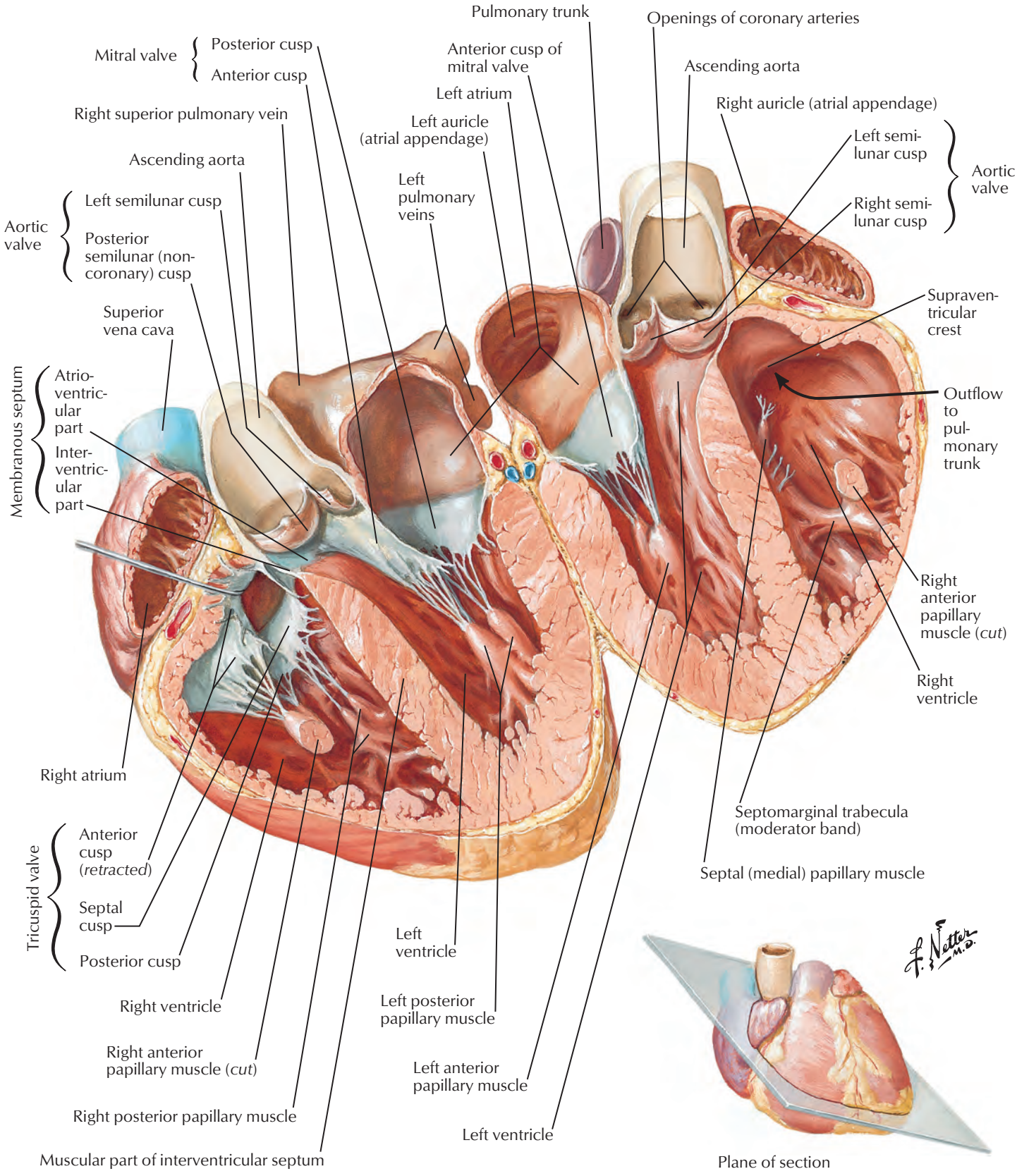
Aortic valve

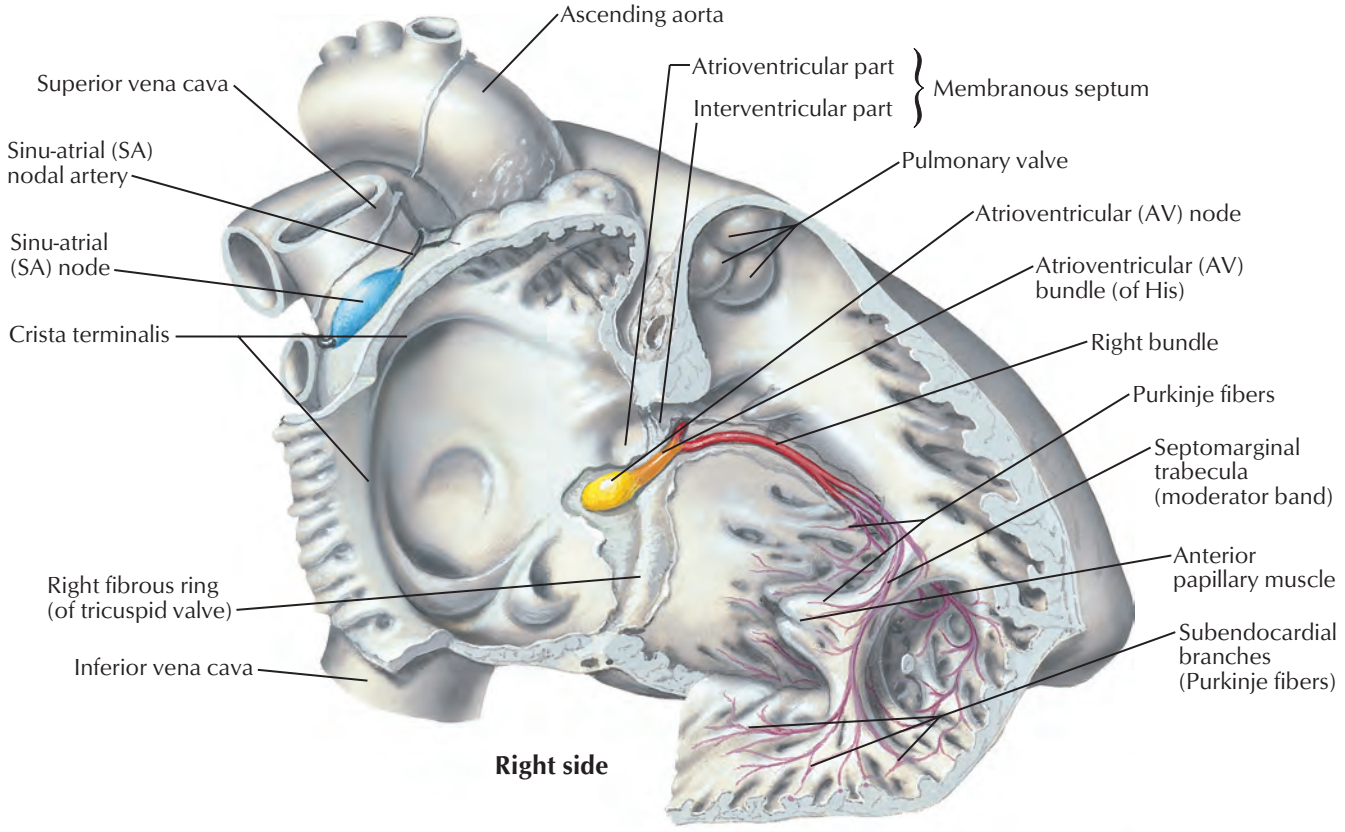


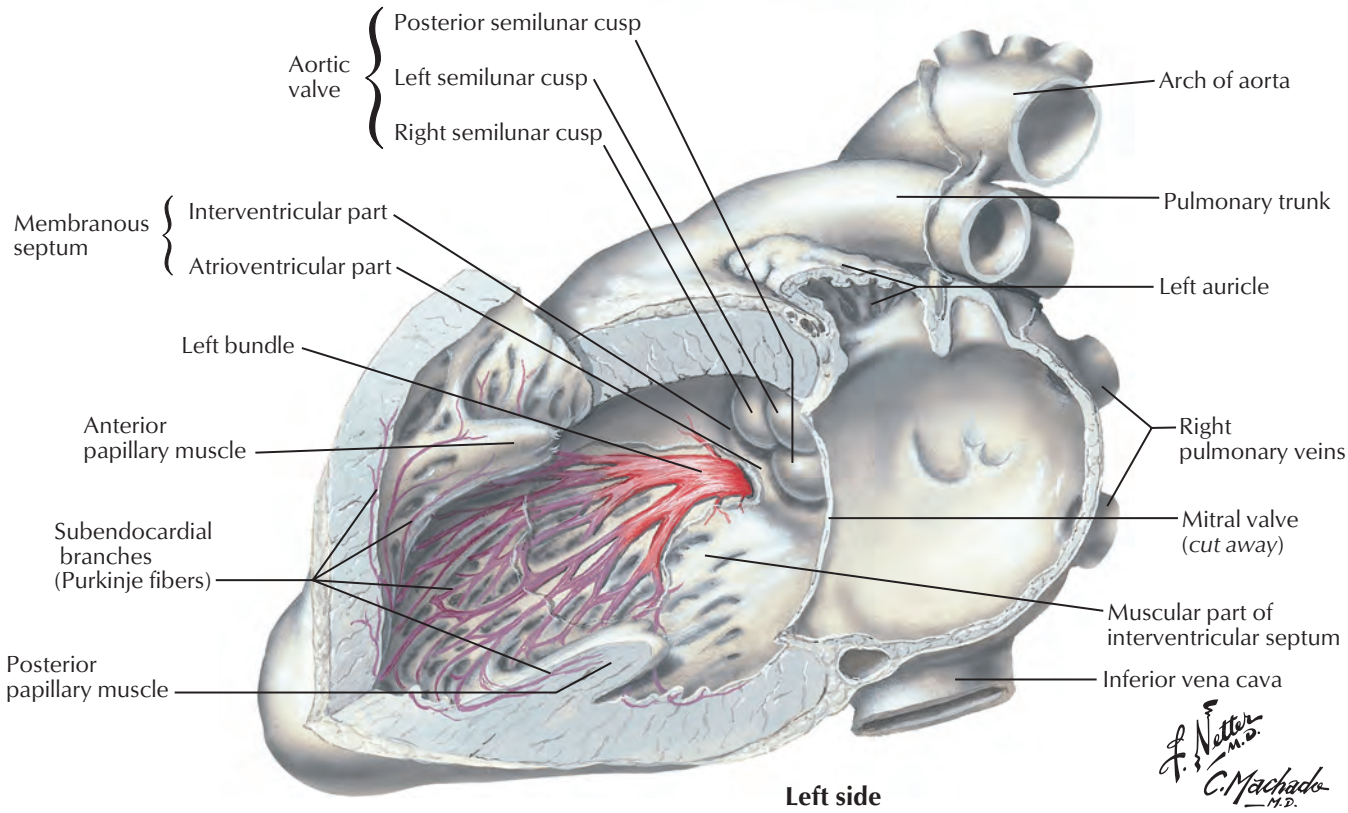
Tricuspid (right atrioventricular) valve

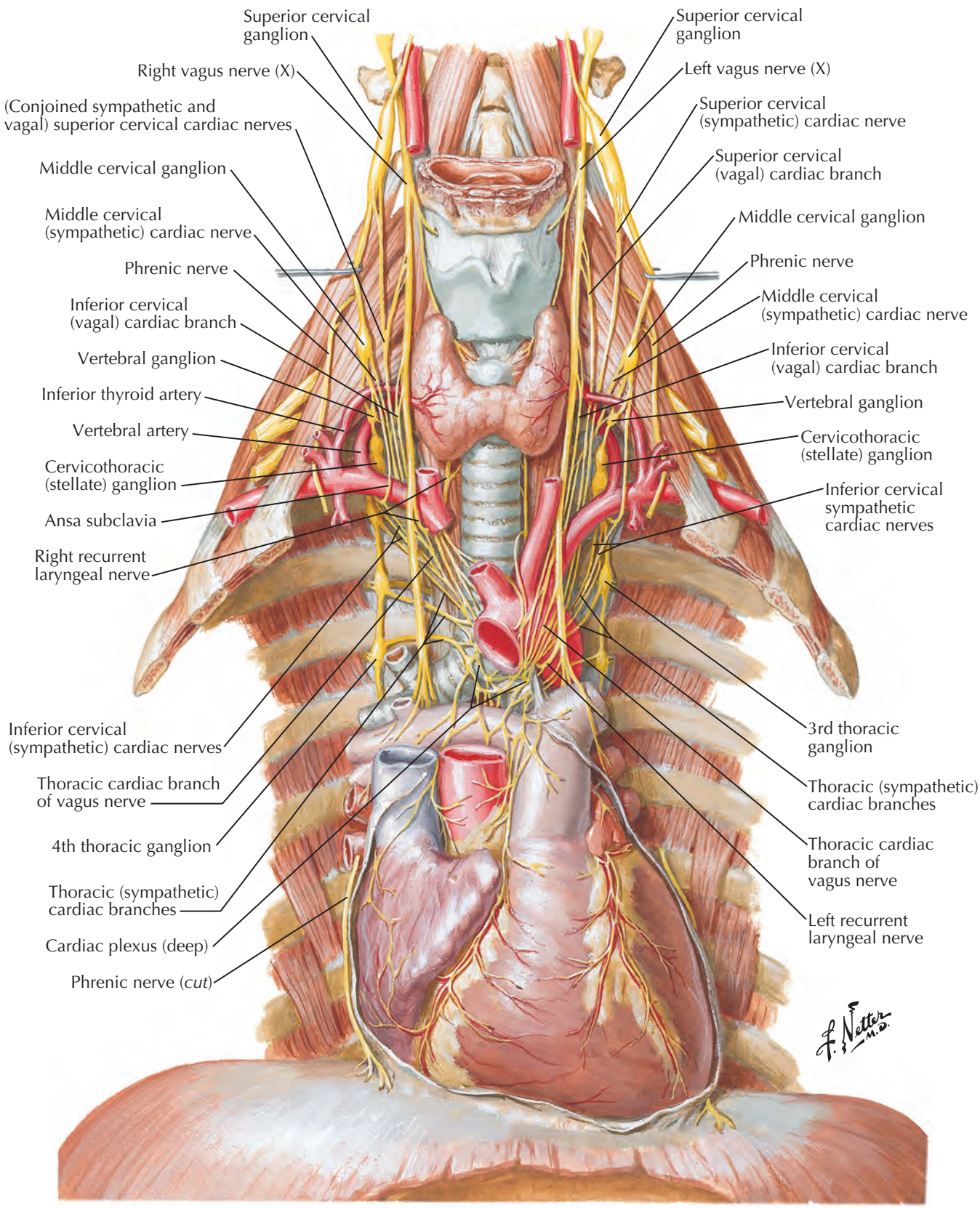


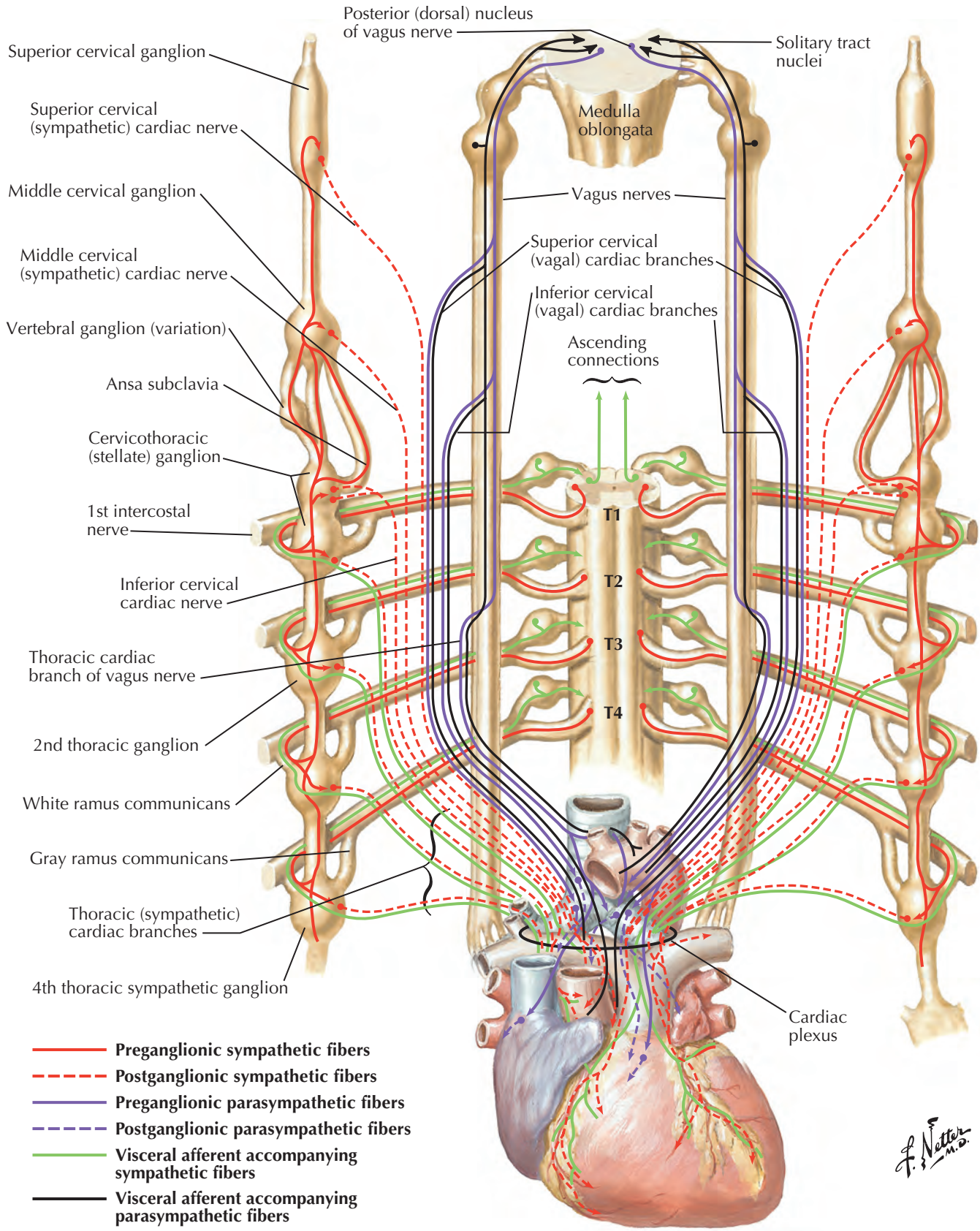
Mitral (left atrioventricular) valve

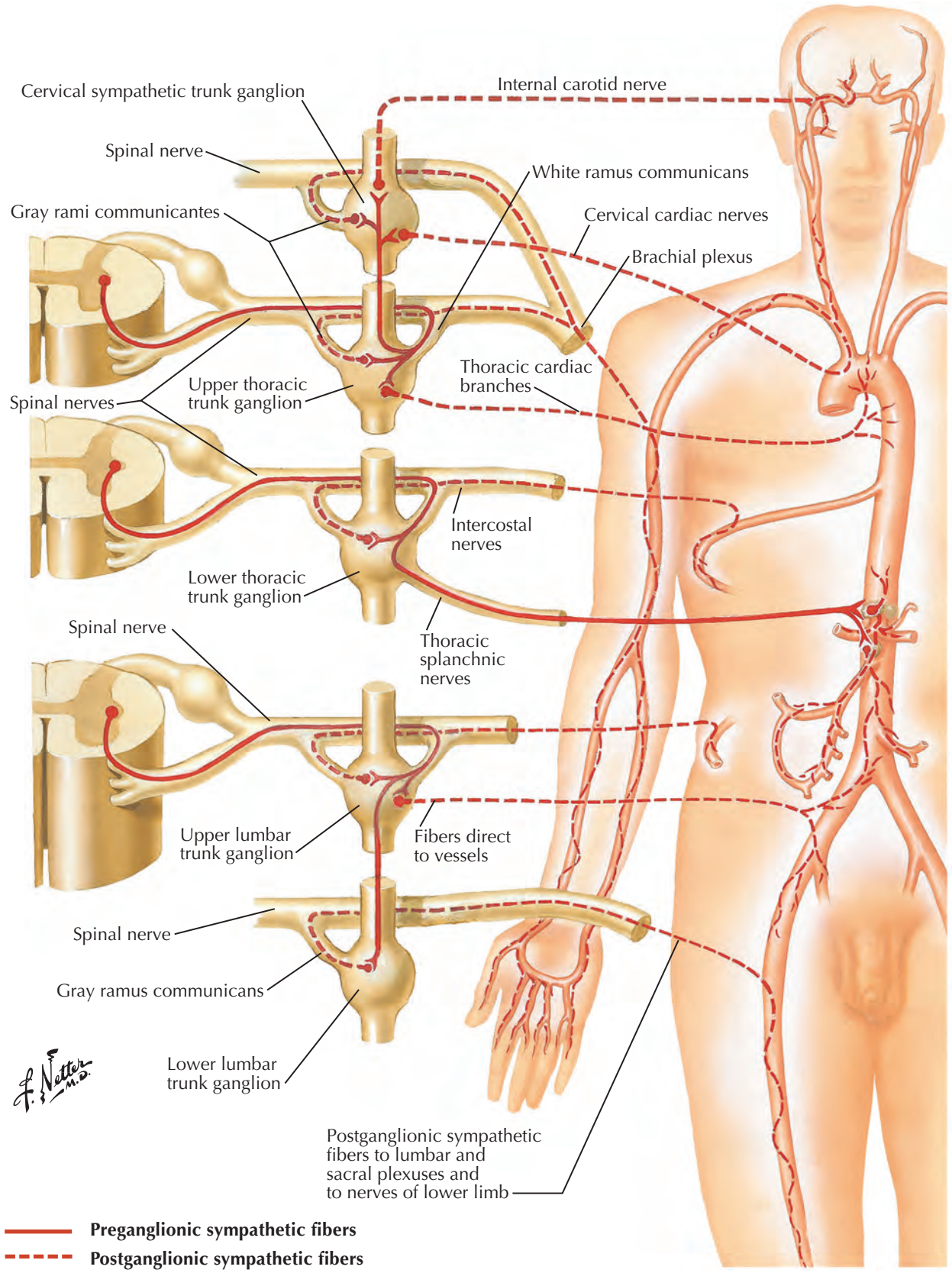

Pulmonary trunk
Openings of coronary arteries
Mitral valve
Posterior cusp
Anterior cusp
Anterior cusp of mitral valve
Ascending aorta
Left atrium
Right auricle (atrial appendage)
Right superior pulmonary vein
Left auricle (atrial appendage)
Left semi-lunar cusp
Aortic valve
Right semi-lunar cusp
Ascending aorta
Left pulmonary veins
Aortic valve
Left semilunar cusp
Posterior semilunar (non-coronary) cusp
Supraventricular crest
Superior vena cava
Membranous septum
Atrioventricular part
Interventricular part
Outflow to pulmonary trunk
Right anterior papillary muscle (cut)
Right ventricle
Right atrium
Septomarginal trabecula (moderator band)
Septal (medial) papillary muscle
Tricuspid valve
Anterior cusp (retracted)
Septal cusp
Posterior cusp
Left ventricle
Right ventricle
Left posterior papillary muscle
Right anterior papillary muscle (cut)
Left anterior papillary muscle
Right posterior papillary muscle
Left ventricle
Muscular part of interventricular septum
Plane of section

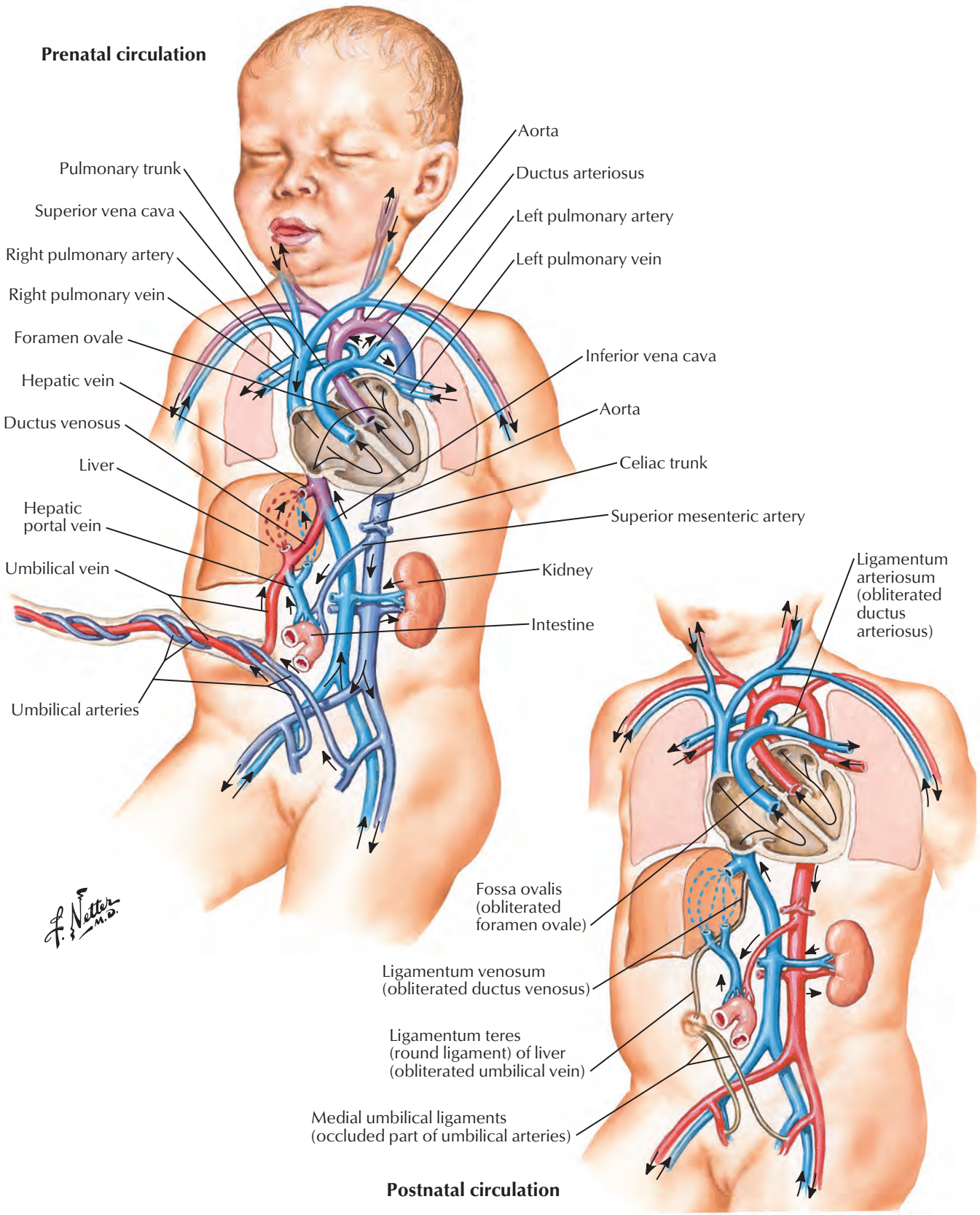

Ascending aorta
Superior vena cava
Atrioventricular part
Interventricular part
Membranous septum
Sinu-atrial (SA) nodal artery
Pulmonary valve
Atrioventricular (AV) node
Sinu-atrial (SA) node
Atrioventricular (AV) bundle (of His)
Crista terminalis
Right bundle
Purkinje fibers
Septomarginal trabecula (moderator band)
Anterior papillary muscle
Right fibrous ring (of tricuspid valve)
Subendocardial branches (Purkinje fibers)
Inferior vena cava
Right side


Aortic valve
Posterior semilunar cusp
Left semilunar cusp
Right semilunar cusp
Arch of aorta
Membranous septum
Interventricular part
Atrioventricular part
Pulmonary trunk
Left auricle
Left bundle
Anterior papillary muscle
Right pulmonary veins
Subendocardial branches (Purkinje fibers)
Mitral valve (cut away)
Muscular part of interventricular septum
Posterior papillary muscle
Inferior vena cava
F. Netter M.D.
C. Machado M.D.
Left side

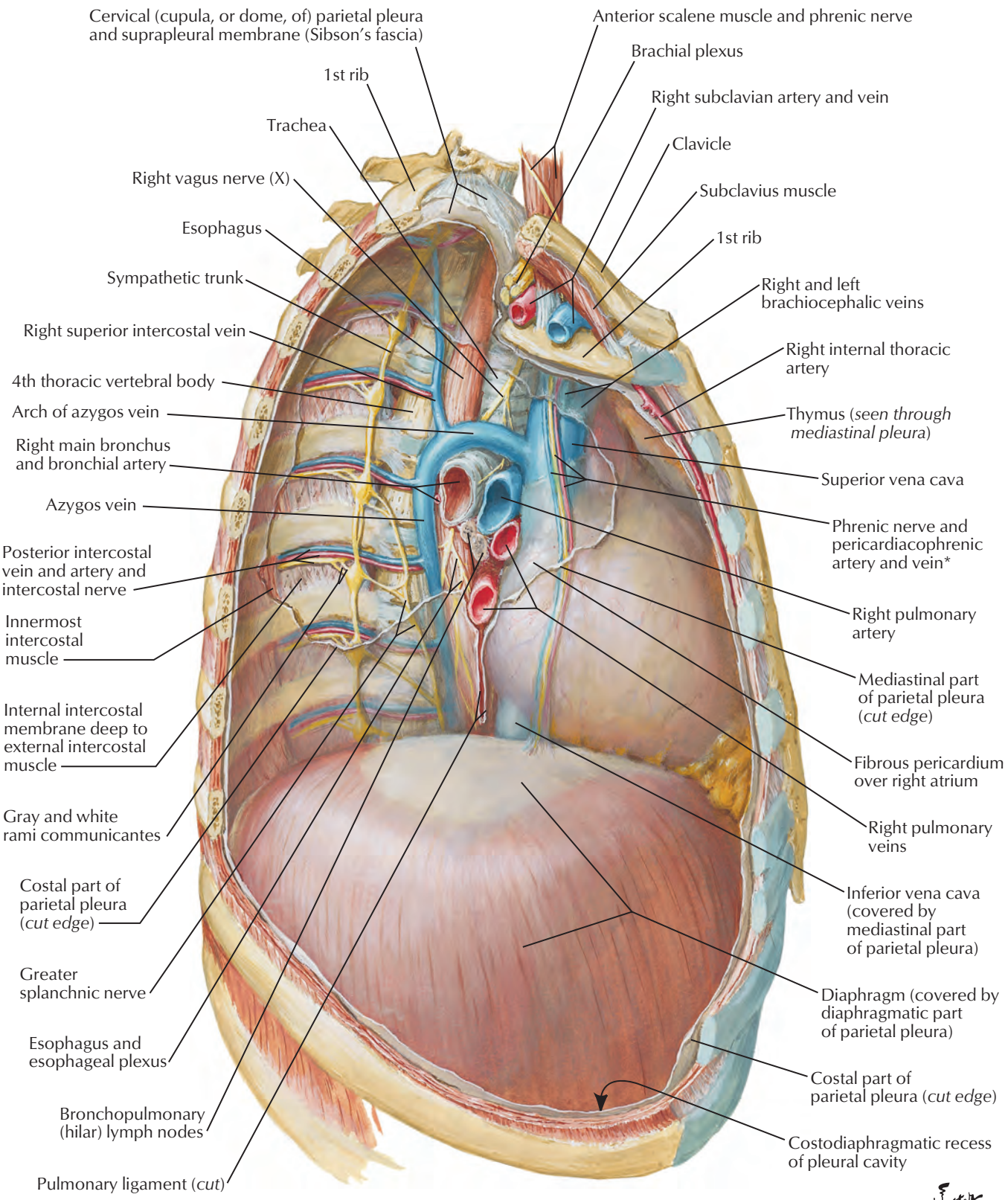

Superior cervical ganglion
Right vagus nerve (X)
(Conjoined sympathetic and vagal) superior cervical cardiac nerves
Middle cervical ganglion
Middle cervical (sympathetic) cardiac nerve
Phrenic nerve
Inferior cervical (vagal) cardiac branch
Vertebral ganglion
Inferior thyroid artery
Vertebral artery
Cervicothoracic (stellate) ganglion
Ansa subclavia
Right recurrent laryngeal nerve
Inferior cervical (sympathetic) cardiac nerves
Thoracic cardiac branch of vagus nerve
4th thoracic ganglion
Thoracic (sympathetic) cardiac branches
Cardiac plexus (deep)
Phrenic nerve (cut)
Superior cervical ganglion
Left vagus nerve (X)
Superior cervical (sympathetic) cardiac nerve
Superior cervical (vagal) cardiac branch
Middle cervical ganglion
Phrenic nerve
Middle cervical (sympathetic) cardiac nerve
Inferior cervical (vagal) cardiac branch
Vertebral ganglion
Cervicothoracic (stellate) ganglion
Inferior cervical sympathetic cardiac nerves
3rd thoracic ganglion
Thoracic (sympathetic) cardiac branches
Thoracic cardiac branch of vagus nerve
Left recurrent laryngeal nerve


Posterior (dorsal) nucleus of vagus nerve
Solitary tract nuclei
Superior cervical ganglion
Medulla oblongata
Superior cervical (sympathetic) cardiac nerve
Middle cervical ganglion
Vagus nerves
Middle cervical (sympathetic) cardiac nerve
Superior cervical (vagal) cardiac branches
Inferior cervical (vagal) cardiac branches
Vertebral ganglion (variation)
Ascending connections
Ansa subclavia
Cervicothoracic (stellate) ganglion
T1
1st intercostal nerve
T2
Inferior cervical cardiac nerve
T3
Thoracic cardiac branch of vagus nerve
T4
2nd thoracic ganglion
White ramus communicans
Gray ramus communicans
Thoracic (sympathetic) cardiac branches
4th thoracic sympathetic ganglion
Cardiac plexus
Preganglionic sympathetic fibers
Postganglionic sympathetic fibers
Preganglionic parasympathetic fibers
Postganglionic parasympathetic fibers
Visceral afferent accompanying sympathetic fibers
Visceral afferent accompanying parasympathetic fibers
F. Netter M.D.

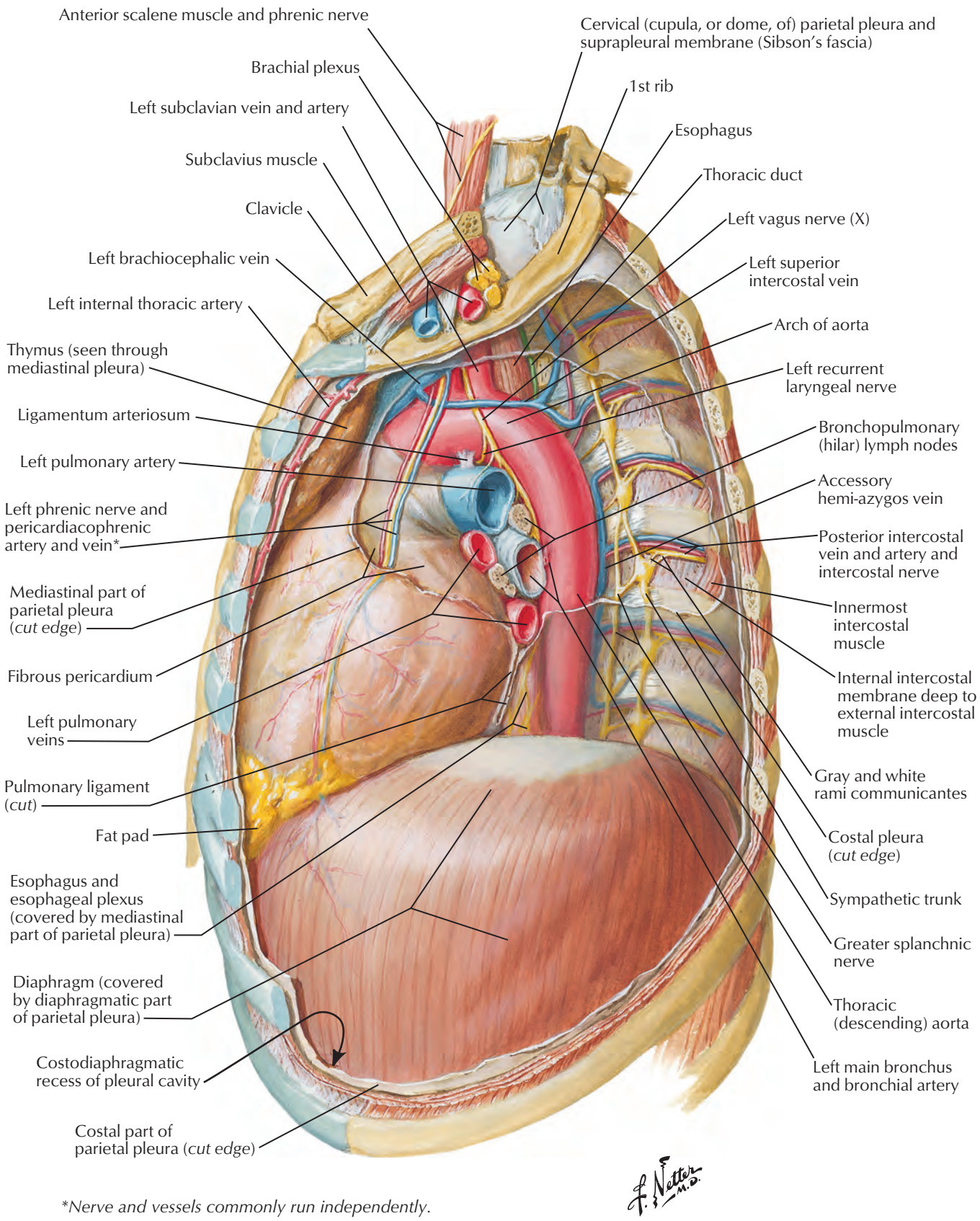

Cervical sympathetic trunk ganglion
Internal carotid nerve
Spinal nerve
White ramus communicans
Gray rami communicantes
Cervical cardiac nerves
Brachial plexus
Thoracic cardiac branches
Upper thoracic trunk ganglion
Spinal nerves
Intercostal nerves
Lower thoracic trunk ganglion
Spinal nerve
Thoracic splanchnic nerves
Upper lumbar trunk ganglion
Fibers direct to vessels
Spinal nerve
Gray ramus communicans
Lower lumbar trunk ganglion
Postganglionic sympathetic fibers to lumbar and sacral plexuses and to nerves of lower limb
Preganglionic sympathetic fibers
Postganglionic sympathetic fibers


Prenatal circulation
Pulmonary trunk
Superior vena cava
Right pulmonary artery
Right pulmonary vein
Foramen ovale
Hepatic vein
Ductus venosus
Liver
Hepatic portal vein
Umbilical vein
Umbilical arteries
Aorta
Ductus arteriosus
Left pulmonary artery
Left pulmonary vein
Inferior vena cava
Aorta
Celiac trunk
Superior mesenteric artery
Kidney
Intestine
F. Netter M.D.
Ligamentum arteriosum (obliterated ductus arteriosus)
Fossa ovalis (obliterated foramen ovale)
Ligamentum venosum (obliterated ductus venosus)
Ligamentum teres (round ligament) of liver (obliterated umbilical vein)
Medial umbilical ligaments (occluded part of umbilical arteries)
Postnatal circulation

Mediastinum: Right Lateral View

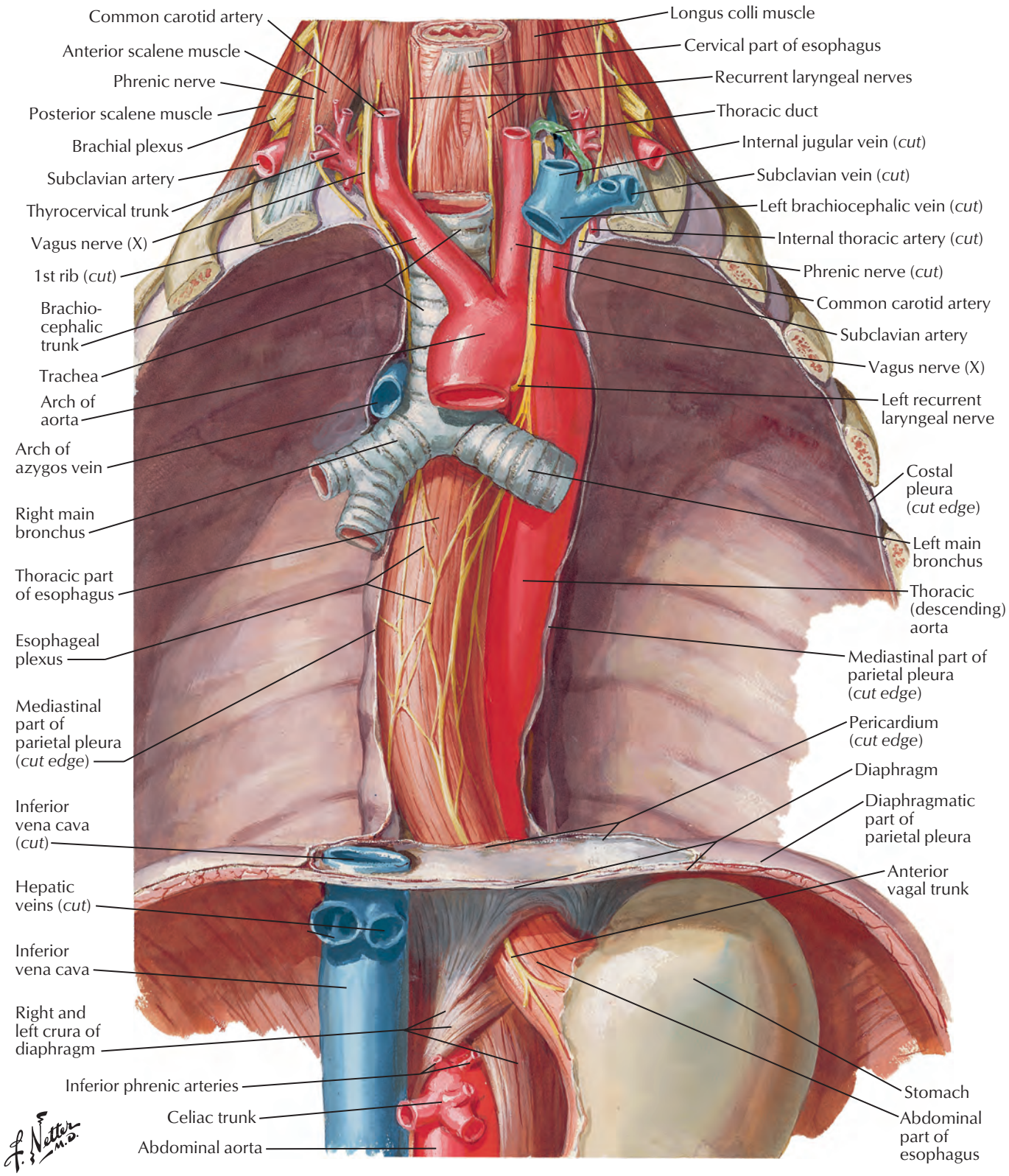


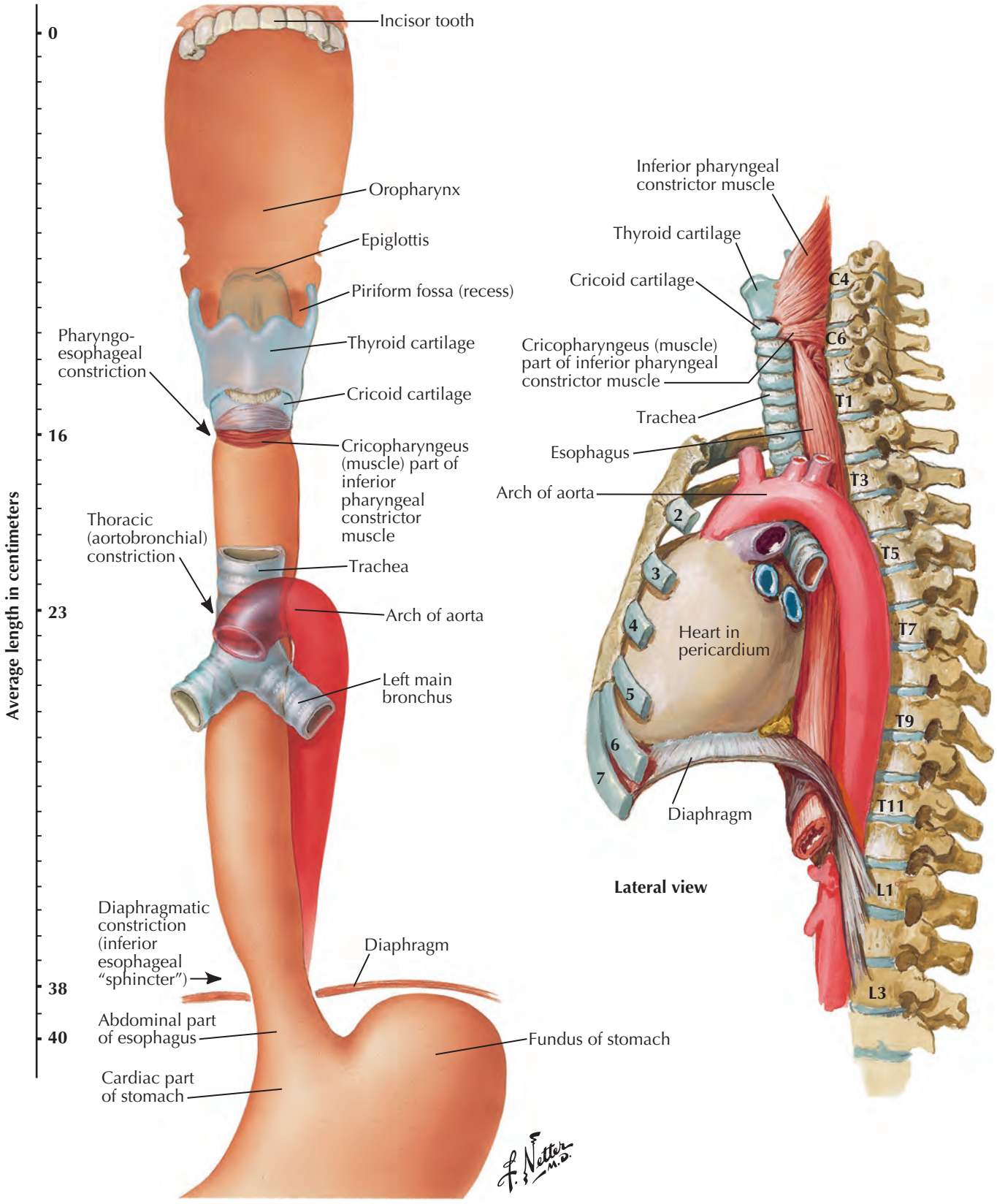
**Nerve and vessels commonly run independently.*



*Nerve and vessels commonly run independently.

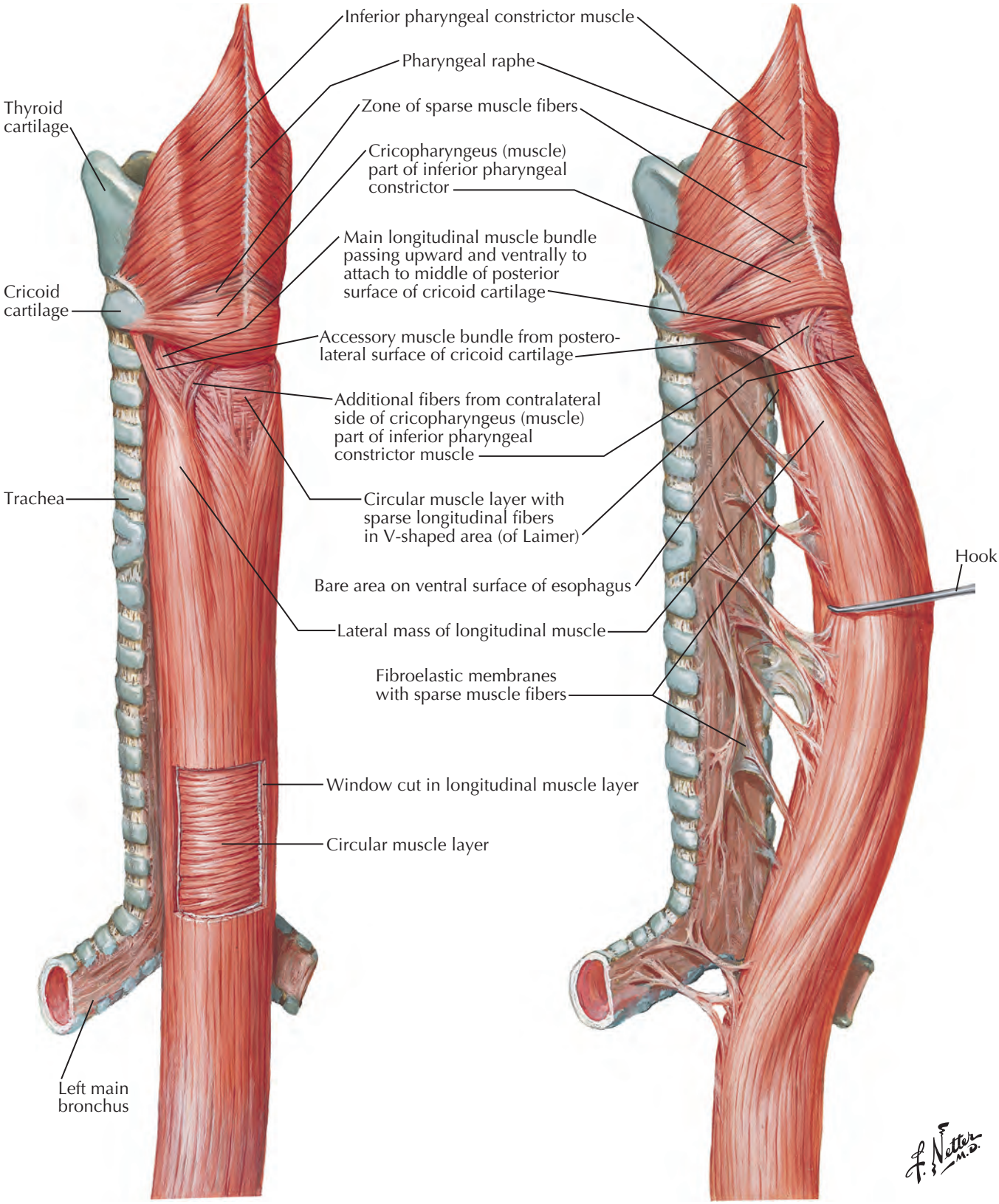
Esophagus in Situ



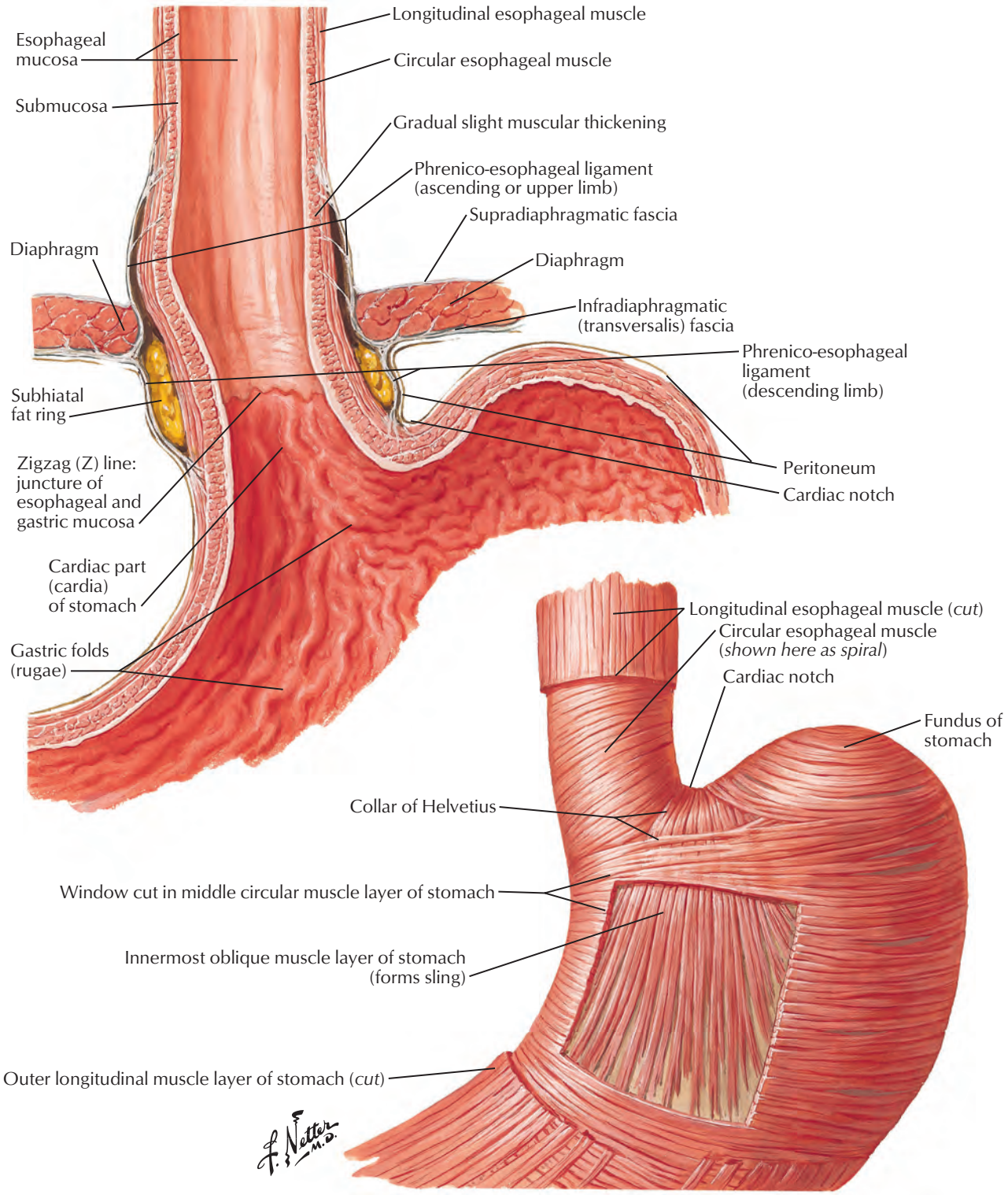

Average length in centimeters
0
16
23
38
40
Incisor tooth
Oropharynx
Epiglottis
Piriform fossa (recess)
Pharyngo-esophageal constriction
Thyroid cartilage
Cricoid cartilage
Cricopharyngeus (muscle) part of inferior pharyngeal constrictor muscle
Thoracic (aortobronchial) constriction
Trachea
Arch of aorta
Left main bronchus
Diaphragmatic constriction (inferior esophageal "sphincter")
Diaphragm
Abdominal part of esophagus
Fundus of stomach
Cardiac part of stomach
Inferior pharyngeal constrictor muscle
Thyroid cartilage
Cricoid cartilage
Cricopharyngeus (muscle) part of inferior pharyngeal constrictor muscle
Trachea
Esophagus
Arch of aorta
Heart in pericardium
Diaphragm
C4
C6
T1
T3
T5
T7
T9
T11
L1
L3
2
3
4
5
6
7
Lateral view

Musculature of Esophagus

See also **Plates 67, 70**

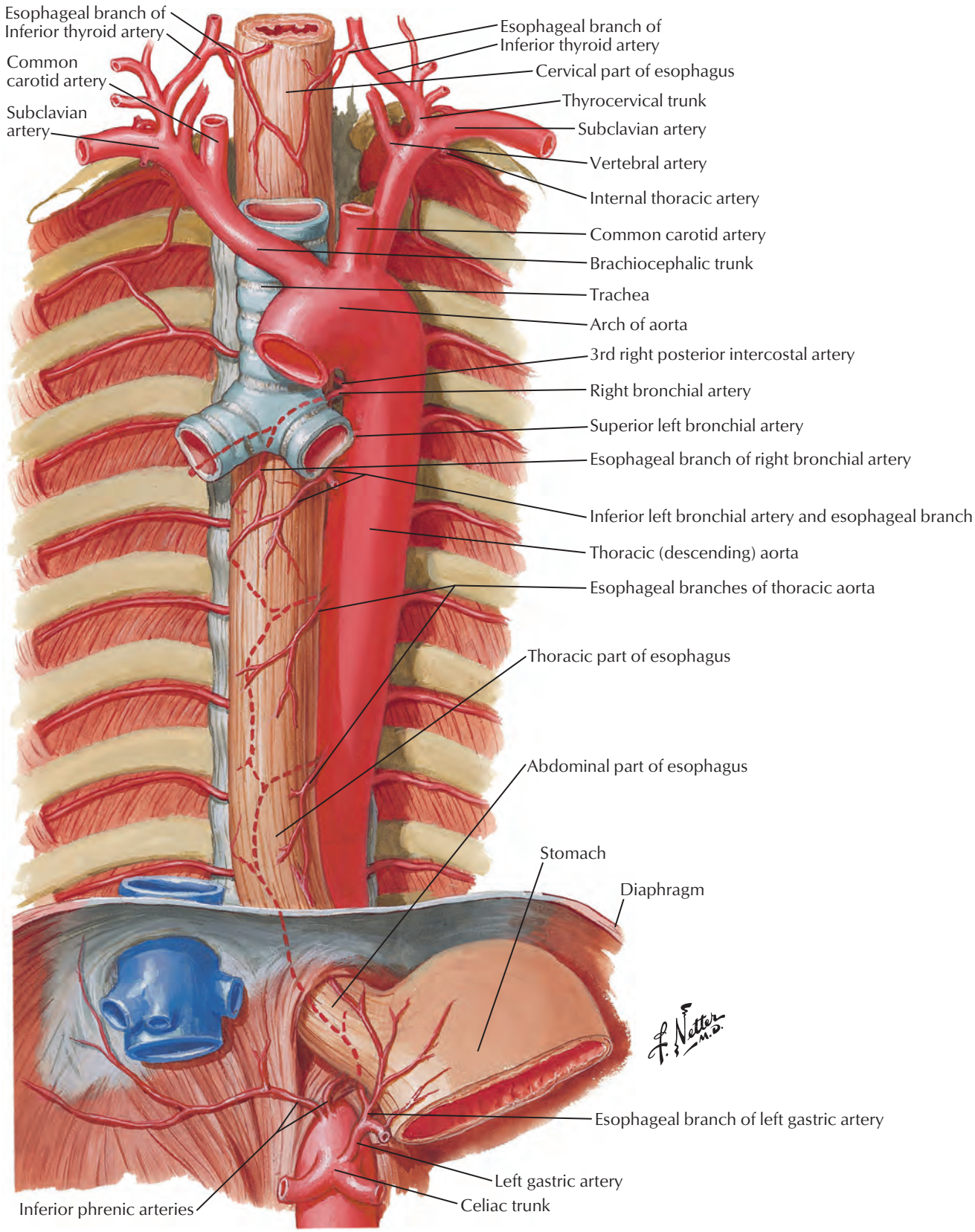


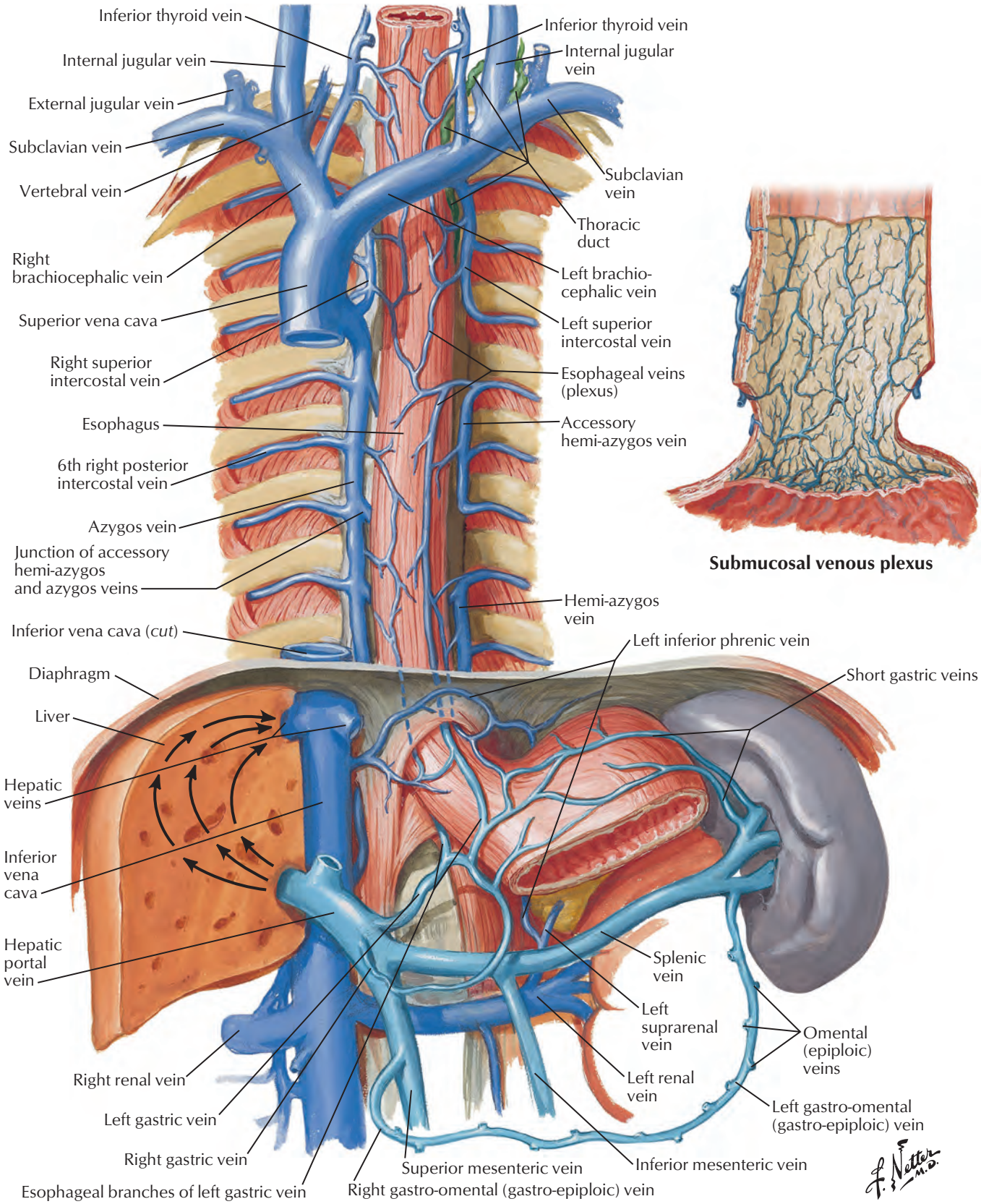
Posterolateral view


Esophageal mucosa
Submucosa
Diaphragm
Subhiatal fat ring
Zigzag (Z) line: juncture of esophageal and gastric mucosa
Cardiac part (cardia) of stomach
Gastric folds (rugae)
Longitudinal esophageal muscle
Circular esophageal muscle
Gradual slight muscular thickening
Phrenico-esophageal ligament (ascending or upper limb)
Supradiaphragmatic fascia
Diaphragm
Infradiaphragmatic (transversalis) fascia
Phrenico-esophageal ligament (descending limb)
Peritoneum
Cardiac notch
Longitudinal esophageal muscle (cut)
Circular esophageal muscle (shown here as spiral)
Cardiac notch
Fundus of stomach
Collar of Helvetius
Window cut in middle circular muscle layer of stomach
Innermost oblique muscle layer of stomach (forms sling)
Outer longitudinal muscle layer of stomach (cut)

Arteries of Esophagus

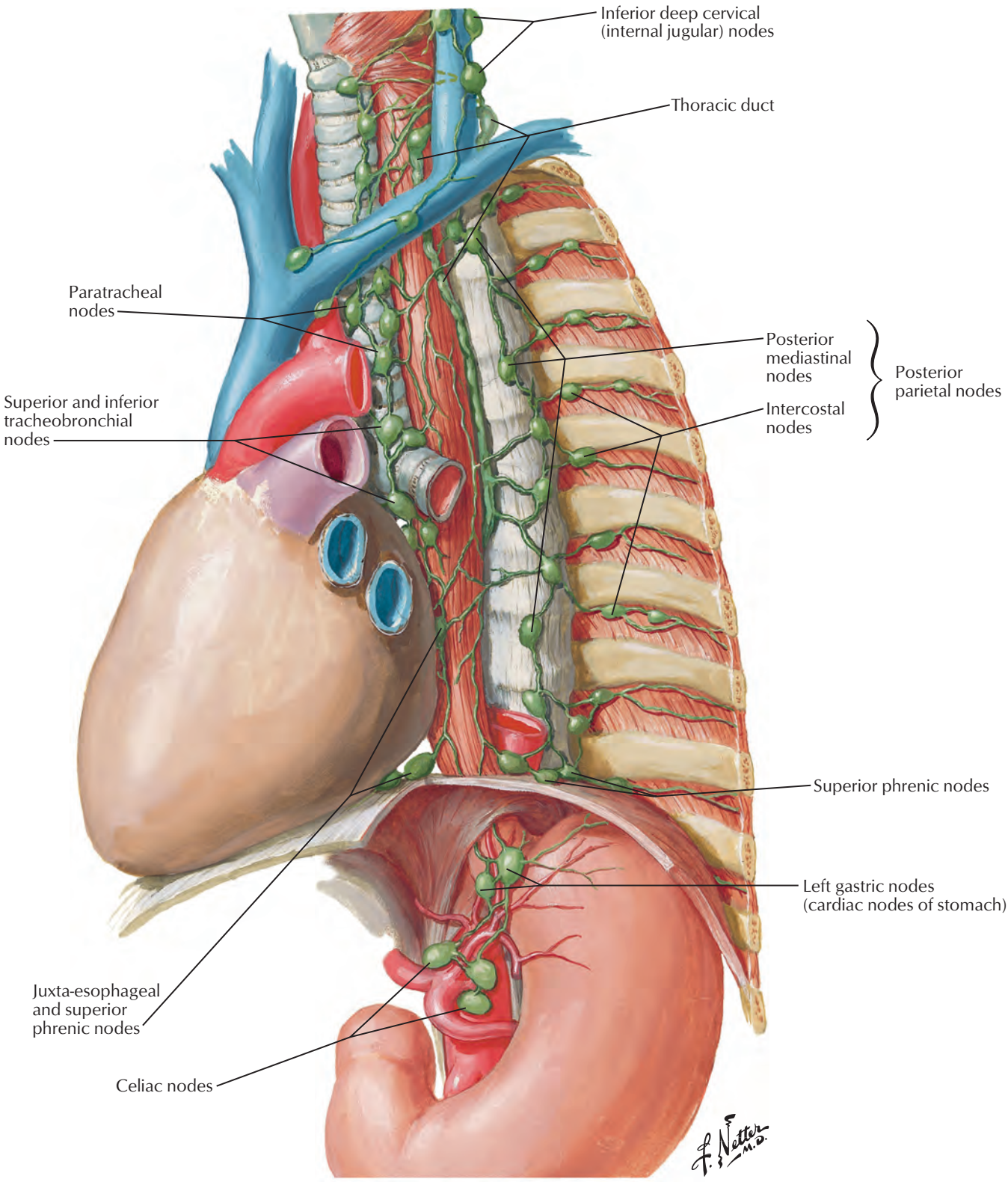
See also Plates 204, 284

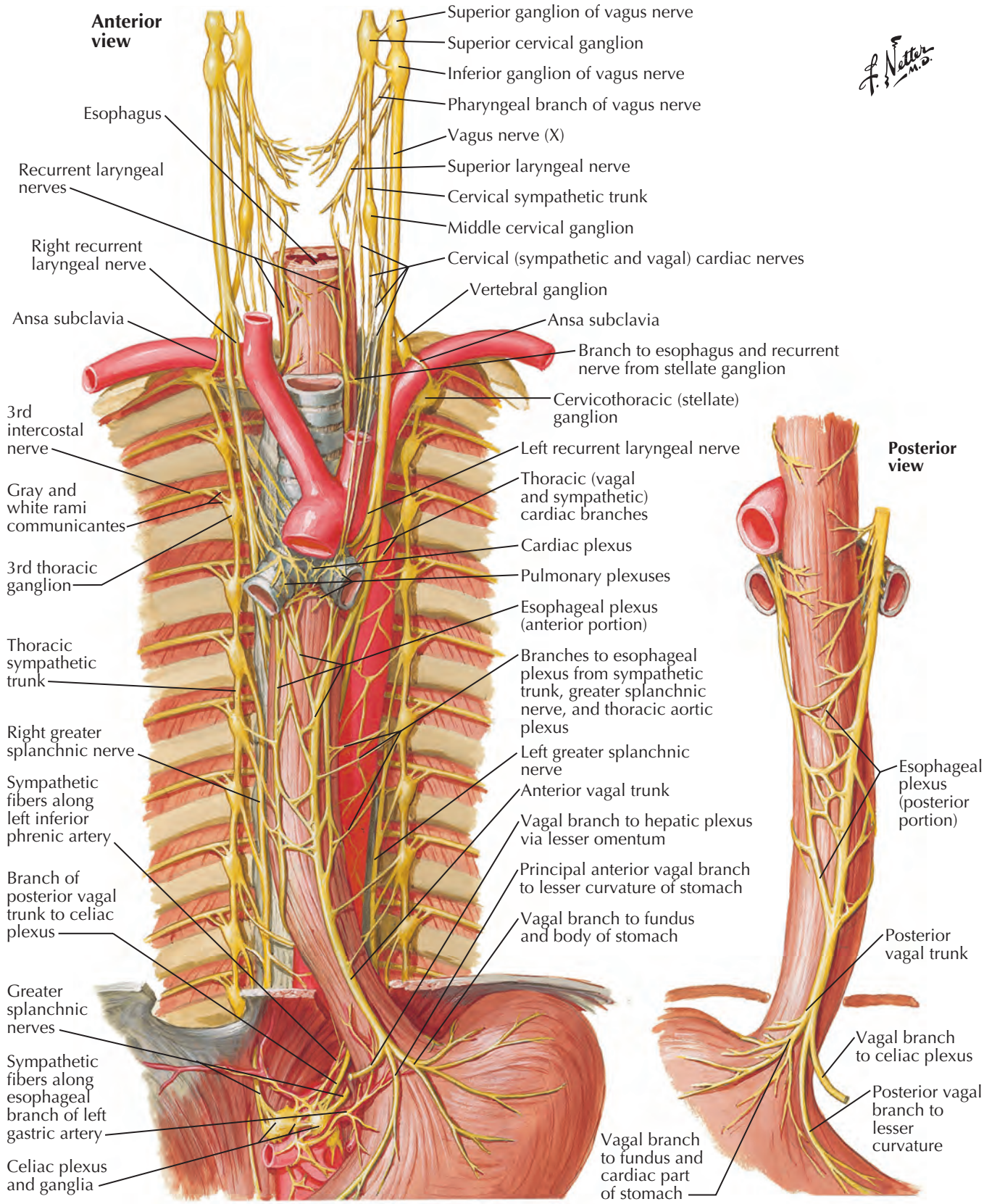



Inferior thyroid vein
Internal jugular vein
External jugular vein
Subclavian vein
Vertebral vein
Right brachiocephalic vein
Superior vena cava
Right superior intercostal vein
Esophagus
6th right posterior intercostal vein
Azygos vein
Junction of accessory hemi-azygos and azygos veins
Inferior vena cava (cut)
Diaphragm
Liver
Hepatic veins
Inferior vena cava
Hepatic portal vein
Right renal vein
Left gastric vein
Right gastric vein
Esophageal branches of left gastric vein
Inferior thyroid vein
Internal jugular vein
Subclavian vein
Thoracic duct
Left brachio-cephalic vein
Left superior intercostal vein
Esophageal veins (plexus)
Accessory hemi-azygos vein
Hemi-azygos vein
Left inferior phrenic vein
Short gastric veins
Splenic vein
Left suprarenal vein
Left renal vein
Omental (epiploic) veins
Left gastro-omental (gastro-epiploic) vein
Inferior mesenteric vein
Superior mesenteric vein
Right gastro-omental (gastro-epiploic) vein
Submucosal venous plexus

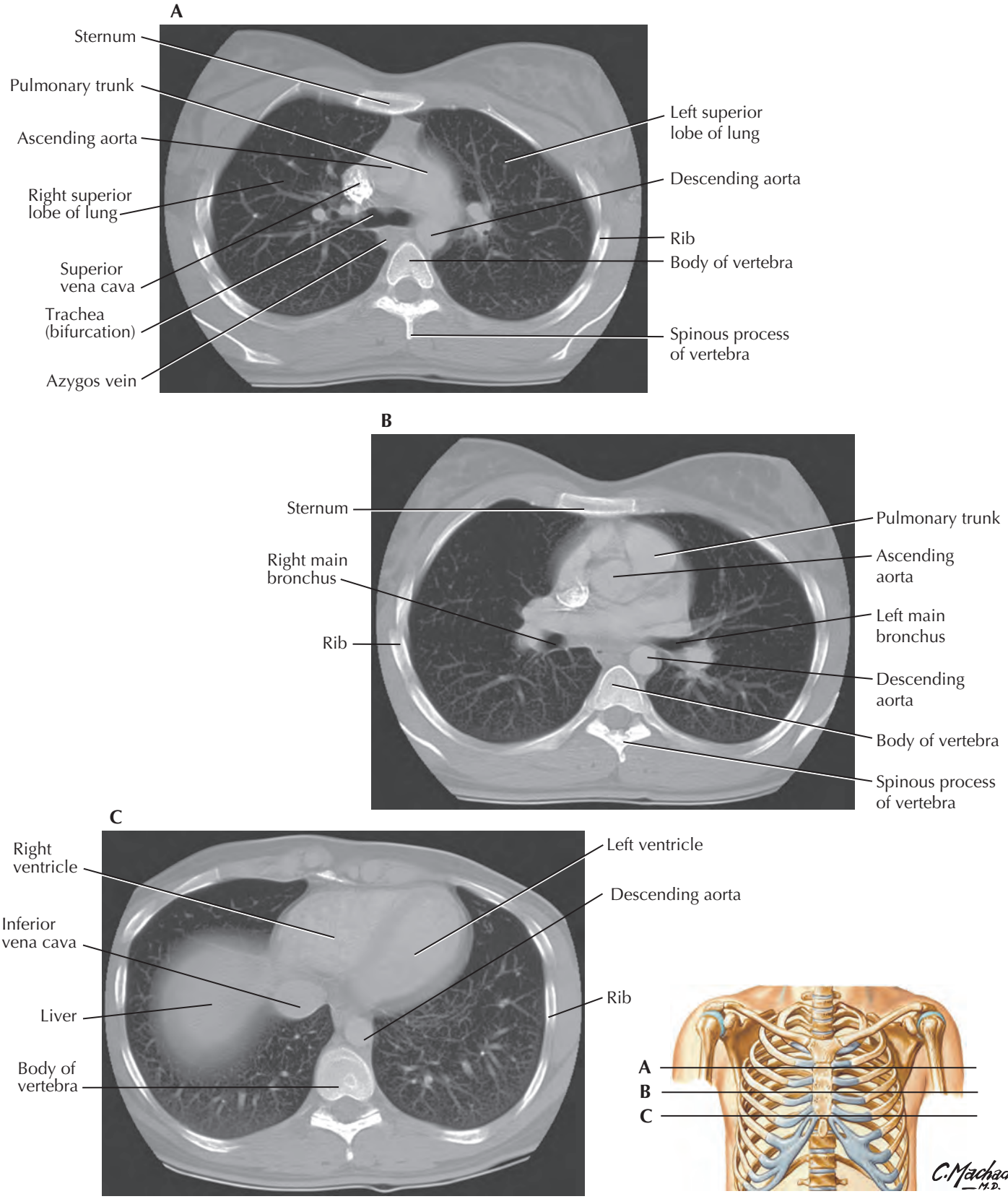
Lymph Vessels and Nodes of Esophagus

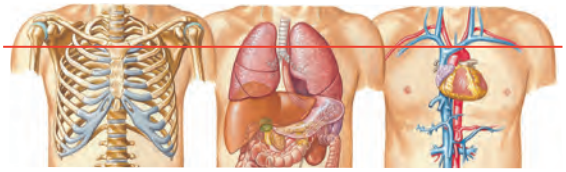
See also Plates 205, 293

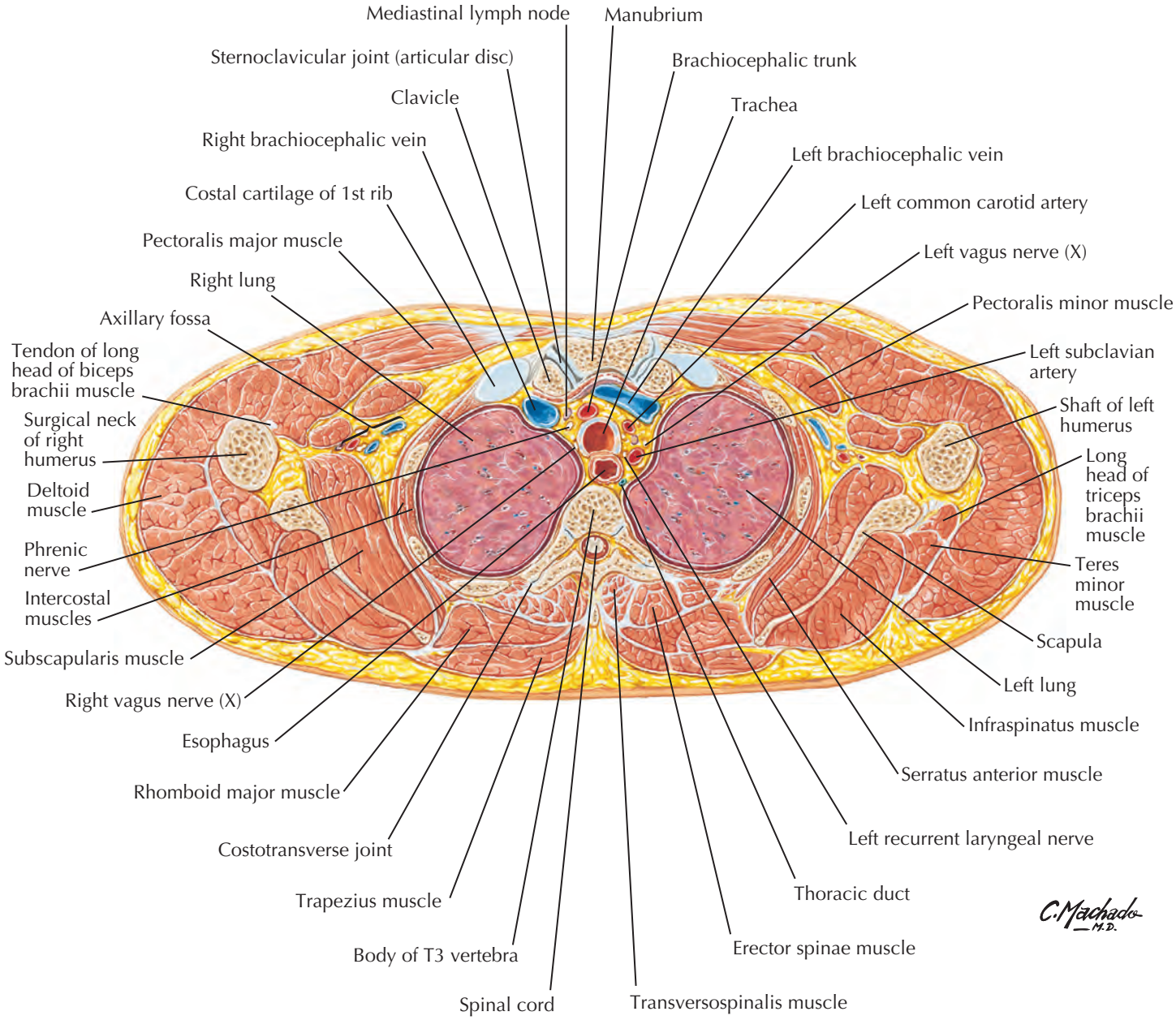



Anterior view
Superior ganglion of vagus nerve
Superior cervical ganglion
Inferior ganglion of vagus nerve
Pharyngeal branch of vagus nerve
Esophagus
Vagus nerve (X)
Recurrent laryngeal nerves
Superior laryngeal nerve
Cervical sympathetic trunk
Middle cervical ganglion
Right recurrent laryngeal nerve
Cervical (sympathetic and vagal) cardiac nerves
Vertebral ganglion
Ansa subclavia
Ansa subclavia
Branch to esophagus and recurrent nerve from stellate ganglion
Cervicothoracic (stellate) ganglion
3rd intercostal nerve
Left recurrent laryngeal nerve
Gray and white rami communicantes
Thoracic (vagal and sympathetic) cardiac branches
3rd thoracic ganglion
Cardiac plexus
Pulmonary plexuses
Esophageal plexus (anterior portion)
Thoracic sympathetic trunk
Branches to esophageal plexus from sympathetic trunk, greater splanchnic nerve, and thoracic aortic plexus
Right greater splanchnic nerve
Left greater splanchnic nerve
Sympathetic fibers along left inferior phrenic artery
Anterior vagal trunk
Vagal branch to hepatic plexus via lesser omentum
Branch of posterior vagal trunk to celiac plexus
Principal anterior vagal branch to lesser curvature of stomach
Vagal branch to fundus and body of stomach
Greater splanchnic nerves
Sympathetic fibers along esophageal branch of left gastric artery
Celiac plexus and ganglia
Vagal branch to fundus and cardiac part of stomach
Posterior view
Esophageal plexus (posterior portion)
Posterior vagal trunk
Vagal branch to celiac plexus
Posterior vagal branch to lesser curvature

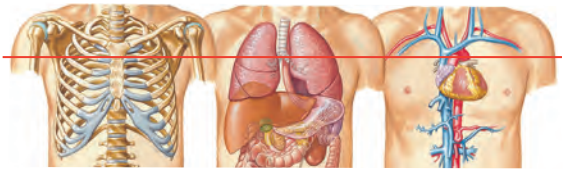
Series of chest axial CT images from superior (A) to inferior (C)

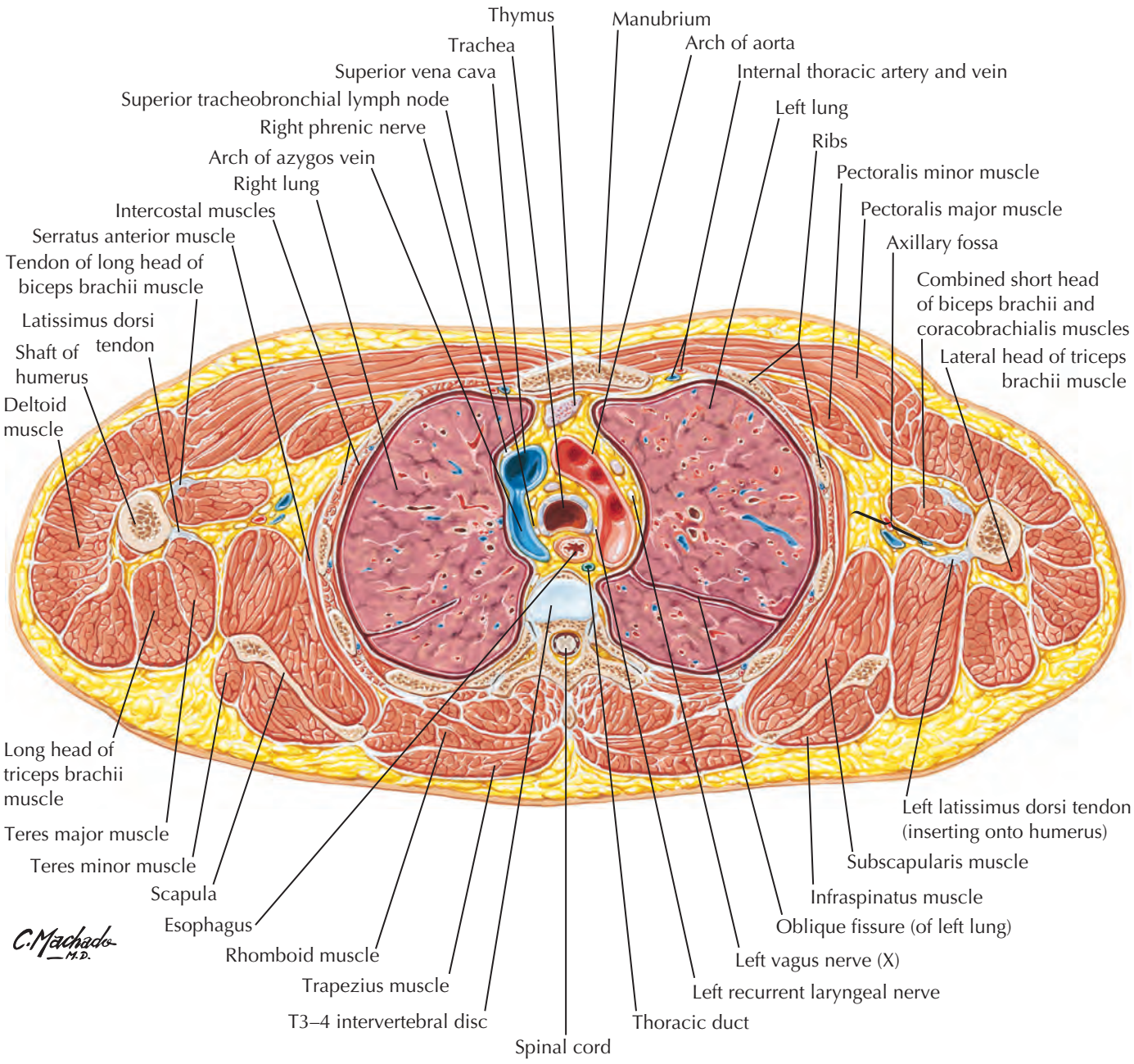


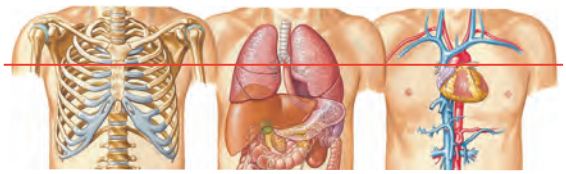


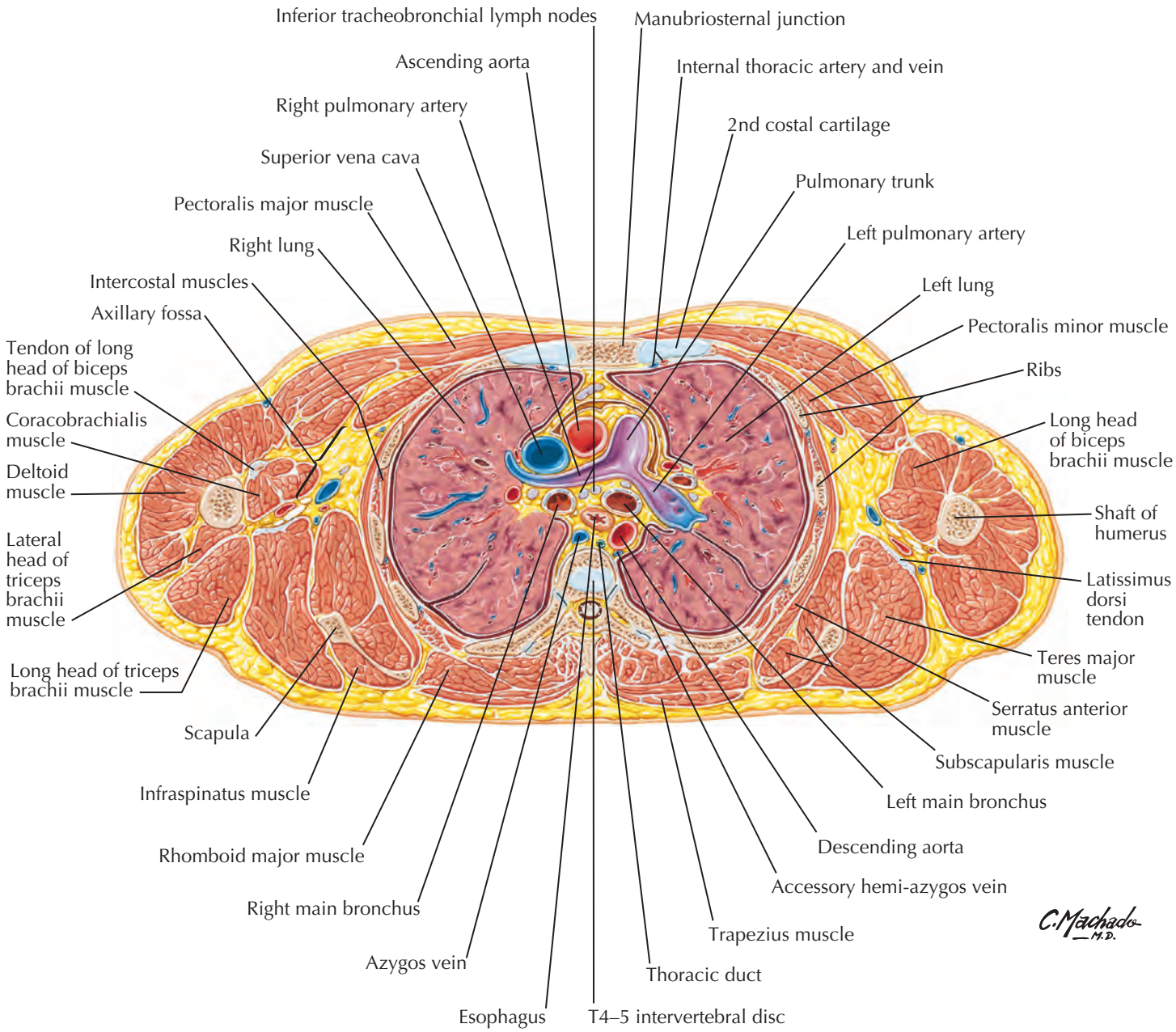

Mediastinal lymph node
Manubrium
Sternoclavicular joint (articular disc)
Brachiocephalic trunk
Clavicle
Trachea
Right brachiocephalic vein
Left brachiocephalic vein
Costal cartilage of 1st rib
Left common carotid artery
Pectoralis major muscle
Left vagus nerve (X)
Right lung
Pectoralis minor muscle
Axillary fossa
Tendon of long head of biceps brachii muscle
Left subclavian artery
Surgical neck of right humerus
Shaft of left humerus
Deltoid muscle
Long head of triceps brachii muscle
Phrenic nerve
Teres minor muscle
Intercostal muscles
Scapula
Subscapularis muscle
Left lung
Right vagus nerve (X)
Infraspinatus muscle
Esophagus
Serratus anterior muscle
Rhomboid major muscle
Left recurrent laryngeal nerve
Costotransverse joint
Thoracic duct
Trapezius muscle
Erector spinae muscle
Body of T3 vertebra
Spinal cord
Transversospinalis muscle
C. Machado M.D.

Cross Section of Thorax at T3-4 Disc Level

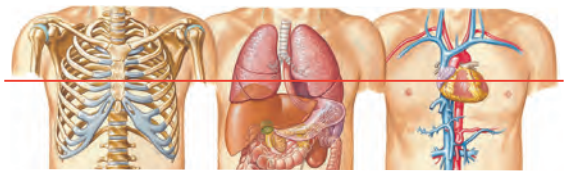


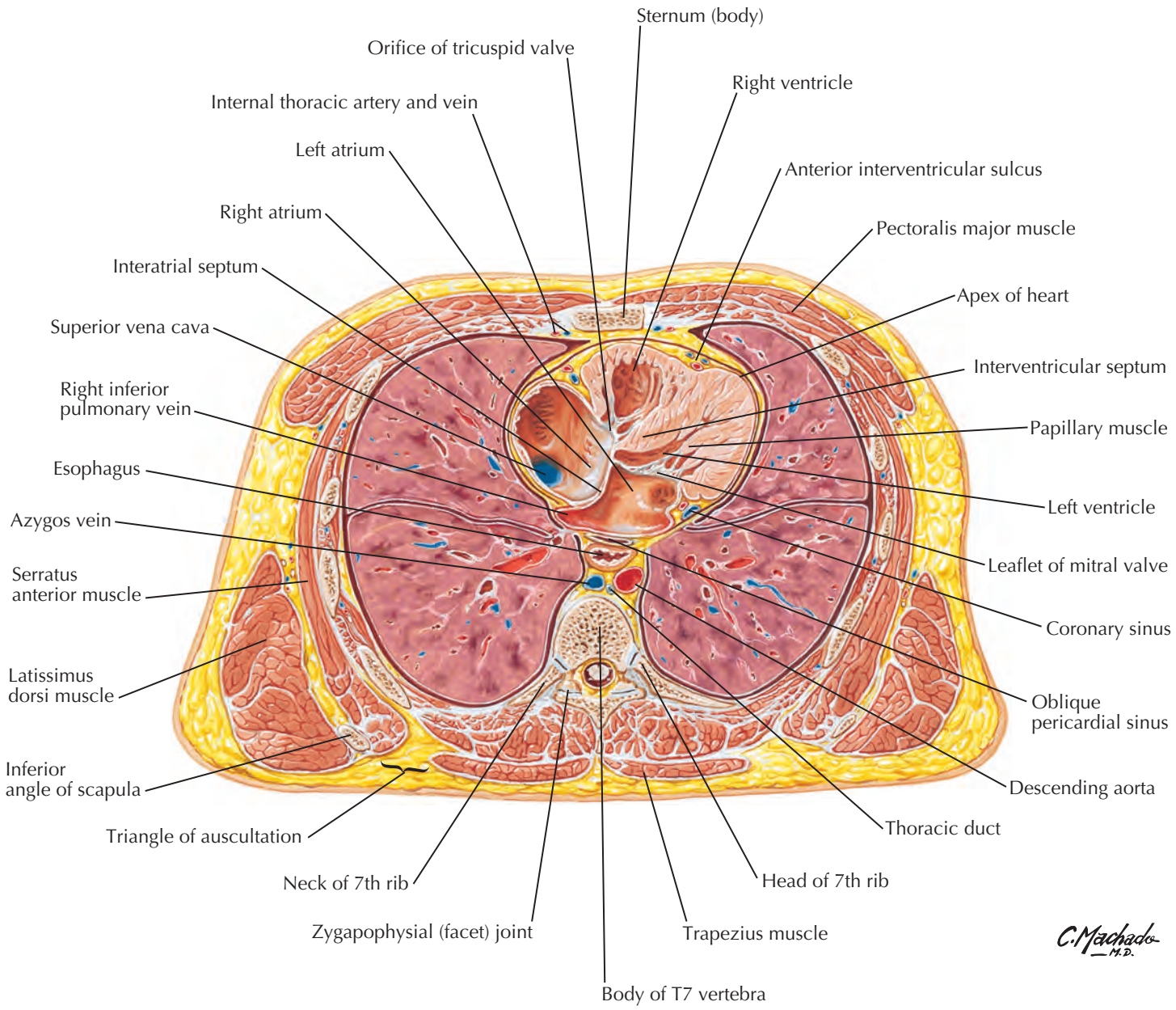





Inferior tracheobronchial lymph nodes
Manubriosternal junction
Ascending aorta
Internal thoracic artery and vein
Right pulmonary artery
2nd costal cartilage
Superior vena cava
Pulmonary trunk
Pectoralis major muscle
Left pulmonary artery
Right lung
Left lung
Intercostal muscles
Axillary fossa
Pectoralis minor muscle
Tendon of long head of biceps brachii muscle
Ribs
Coracobrachialis muscle
Long head of biceps brachii muscle
Deltoid muscle
Shaft of humerus
Lateral head of triceps brachii muscle
Latissimus dorsi tendon
Teres major muscle
Long head of triceps brachii muscle
Serratus anterior muscle
Scapula
Subscapularis muscle
Infraspinatus muscle
Left main bronchus
Descending aorta
Rhomboid major muscle
Accessory hemi-azygos vein
Right main bronchus
Trapezius muscle
Azygos vein
Thoracic duct
Esophagus
T4–5 intervertebral disc
C. Machado M.D.

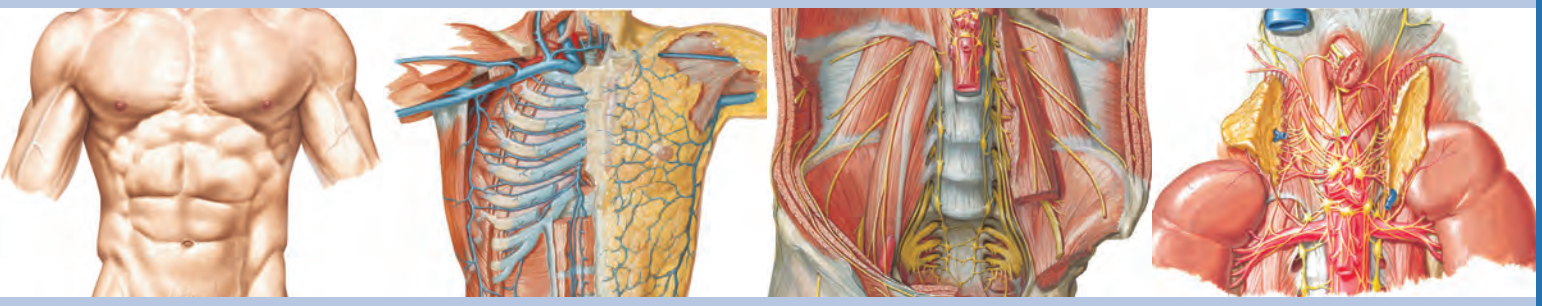
Cross Section of Thorax at T7 Level





MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Diaphragm	Xiphoid process, lower six costal cartilages, L1–L3 vertebrae	Converge into central tendon	Phrenic nerve	Draws central tendon down and forward during inspiration	Pericardiacophrenic, musculophrenic, superior and inferior phrenic arteries	Posterior abdominal wall
External intercostal	Lower border of ribs	Upper border of rib below rib of origin	Intercostal nerves	Supports intercostal spaces in inspiration and expiration, elevates ribs in inspiration	Posterior intercostal arteries, collateral branches of posterior intercostal arteries, costocervical trunk, anterior intercostal branches of internal thoracic artery, musculophrenic artery	Thoracic wall
Innermost intercostal	Lower border of ribs	Upper border of rib below rib of origin	Intercostal nerves	Elevates ribs	Muscular branches of anterior intercostal arteries, muscular branches of posterior intercostal arteries, intercostal branches of internal thoracic and musculophrenic arteries, costocervical trunk branches	Thoracic wall
Internal intercostal	Lower border of ribs	Costal cartilage and edge of costal groove of rib above rib of origin	Intercostal nerves	Prevents pushing out or drawing in of intercostal spaces in inspiration and expiration, lowers ribs in forced expiration	Muscular branches of anterior intercostal arteries, muscular branches of posterior intercostal arteries, intercostal branches of internal thoracic and musculophrenic arteries, costocervical trunk branches	Thoracic wall
Levator costarum	Transverse processes of C7 and T1–T11	Subjacent ribs between tubercle and angle	Dorsal ramus of lower thoracic nerves	Elevates ribs	Posterior intercostal arteries	Thoracic wall
Pectoralis major	Sternal half of clavicle, sternum to 7th rib, cartilages of true ribs, aponeurosis of external oblique muscle	Lateral lip of intertubercular sulcus of humerus	Medial and lateral pectoral nerves	Flexes and adducts arm, rotates arm medially	Pectoral branch of thoraco-acromial artery, perforating branches of internal thoracic artery	Pectoral/axilla region
Pectoralis minor	Outer surface of upper margin of ribs 3–5	Coracoid process of scapula	Medial pectoral nerve	Lowers lateral angle of scapula and protracts scapula	Pectoral branch of thoraco-acromial and intercostal lateral thoracic arteries	Pectoral/axilla region
Serratus anterior	Lateral surfaces of upper 8–9 ribs	Costal surface of medial border of scapula	Long thoracic nerve	Protracts scapula and holds it against thoracic wall	Lateral thoracic artery	Pectoral/axilla region
Serratus posterior inferior	Spinous processes of T11–L2	Inferior aspect of ribs 9–12	Ventral rami of lower thoracic nerves	Depresses ribs	Posterior intercostal arteries	Superficial back
Serratus posterior superior	Ligamentum nuchae, spinous processes of C7–T3	Superior aspect of ribs 2–4	Ventral rami of upper thoracic nerves	Elevates ribs	Posterior intercostal arteries	Superficial back
Subcostal	Internal surface of lower ribs near their angles	Superior borders of 2nd or 3rd rib below	Intercostal nerves	Depresses ribs	Posterior intercostal artery, musculophrenic artery	Thoracic wall
Transversus thoracis	Internal surface of costal cartilages 2–6	Posterior surface of lower sternum	Intercostal nerves	Depresses ribs and costal cartilages	Anterior intercostal arteries, internal thoracic artery	Thoracic wall

Variations in spinal nerve contributions to the innervation of muscles, their arterial supply, their attachments, and their actions are common themes in human anatomy. Therefore, expect differences between texts and realize that anatomical variation is normal.



Section

4 ABDOMEN

Topographic Anatomy

Plate 242

242 Abdomen: Surface Anatomy

Body Wall

Plates 243–262

243 Bony Framework of Abdomen
244 Regions and Planes of Abdomen
245 Anterior Abdominal Wall: Superficial Dissection
246 Anterior Abdominal Wall: Intermediate Dissection
247 Anterior Abdominal Wall: Deep Dissection
248 Rectus Sheath: Cross Section
249 Anterior Abdominal Wall: Internal View
250 Posterolateral Abdominal Wall
251 Arteries of Anterior Abdominal Wall
252 Veins of Anterior Abdominal Wall
253 Nerves of Anterior Abdominal Wall
254 Thoracoabdominal Nerves
255 Inguinal Region: Dissections
256 Inguinal Canal and Spermatic Cord
257 Femoral Sheath and Inguinal Canal
258 Posterior Abdominal Wall: Internal View
259 Arteries of Posterior Abdominal Wall
260 Veins of Posterior Abdominal Wall
261 Lymph Vessels and Nodes of Posterior Abdominal Wall
262 Nerves of Posterior Abdominal Wall

Peritoneal Cavity

Plates 263–268

263 Greater Omentum and Abdominal Viscera

264 Mesenteric Relations of Intestines

265 Mesenteric Relations of Intestines (continued)

266 Omental Bursa: Stomach Reflected

267 Omental Bursa: Cross Section

268 Peritoneum of Posterior Abdominal Wall

Viscera (Gut)

Plates 269–276

269 Stomach in Situ

270 Mucosa of Stomach

271 Duodenum in Situ

272 Mucosa and Musculature of Duodenum

273 Ileocecal Region

274 Ileocecal Region (continued)

275 (Vermiform) Appendix

276 Mucosa and Musculature of Large Intestine

Viscera (Accessory Organs)

Plates 277–282

277 Surfaces and Bed of Liver

278 Liver in Situ: Vascular and Duct Systems

279 Liver Structure: Schema

280 Gallbladder, Extrahepatic Bile Ducts, and Pancreatic Duct

281 Pancreas in Situ

282 Spleen

Visceral Vasculature

Plates 283–296

283 Arteries of Stomach, Liver, and Spleen

284 Arteries of Liver, Pancreas, Duodenum, and Spleen

285 Celiac Arteriogram and CT Angiogram

286 Arteries of Duodenum and Head of Pancreas

287 Arteries of Small Intestine

288 Arteries of Large Intestine

289 Veins of Stomach, Duodenum, Pancreas, and Spleen

290 Veins of Small Intestine

291 Veins of Large Intestine

292 Hepatic Portal Vein Tributaries: Portacaval Anastomoses

293 Lymph Vessels and Nodes of Stomach

294 Lymph Vessels and Nodes of Pancreas

295 Lymph Vessels and Nodes of Small Intestine

296 Lymph Vessels and Nodes of Large Intestine

Innervation

Pates 297–307

297 Autonomic Nerves and Ganglia of Abdomen

298 Autonomic Innervation of Stomach and Duodenum

299 Autonomic Innervation of Stomach and Duodenum (continued)

300 Autonomic Innervation of Stomach and Duodenum: Schema

301 Autonomic Innervation of Small Intestine

302 Autonomic Innervation of Large Intestine

303 Autonomic Innervation of Small and Large Intestines: Schema

304 Autonomic Reflex Pathways: Schema

305 Intrinsic Autonomic Plexuses of Intestine: Schema

306 Autonomic Innervation of Liver and Biliary Tract: Schema

307 Autonomic Innervation of Pancreas: Schema

Kidneys and Suprarenal Glands

Plates 308–320

308 Kidneys in Situ: Anterior Views

309 Kidneys in Situ: Posterior Views

310 Renal Artery and Vein in Situ

311 Gross Structure of Kidney

312 Intrarenal Arteries and Renal Segments

313 Ureters in Abdomen and Pelvis

314 Arteries of Ureters and Urinary Bladder

315 Renal Fasciae

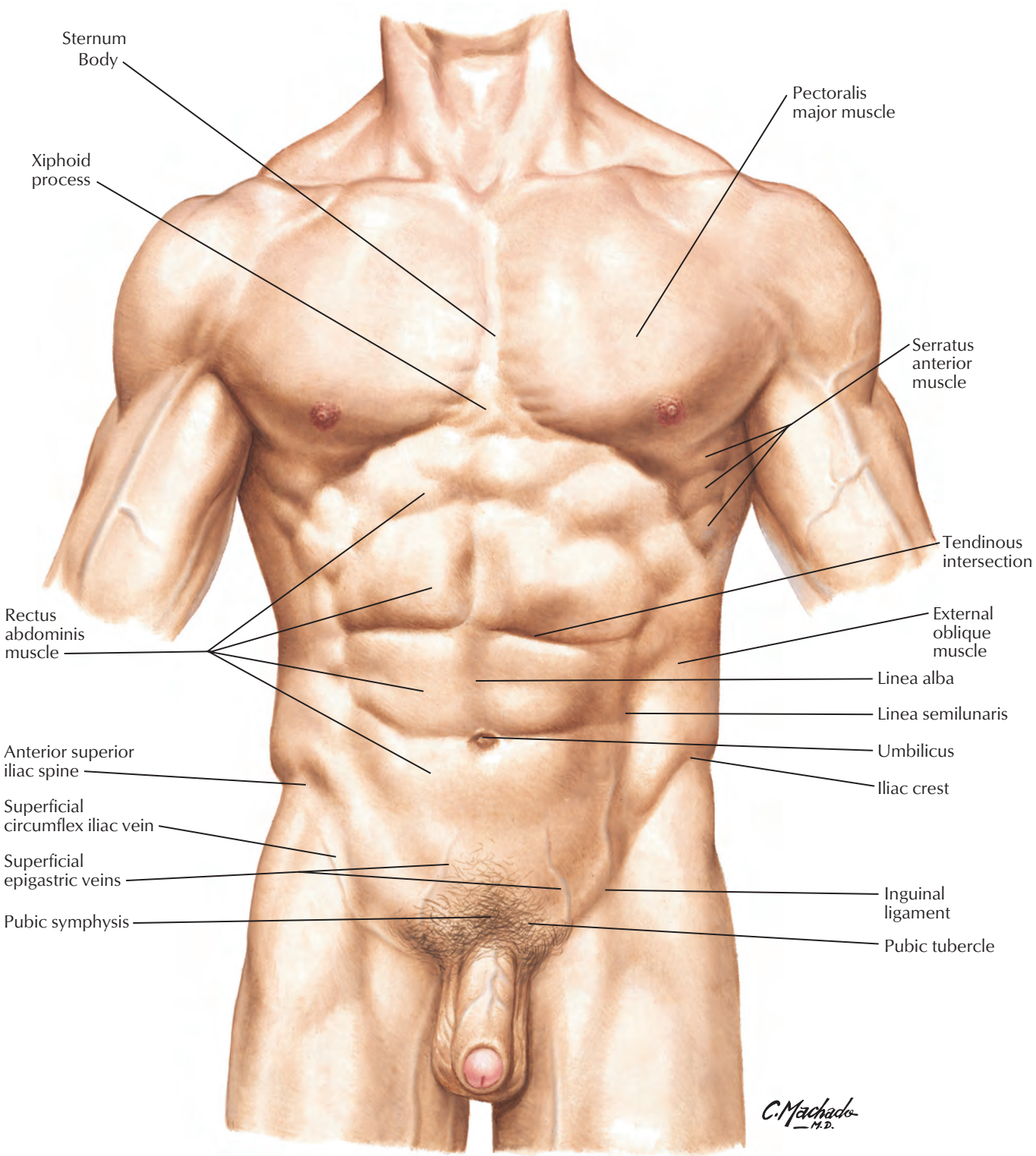
316 Lymph Vessels and Nodes of Kidneys and Urinary Bladder
317 Autonomic Nerves of Kidneys, Ureters, and Urinary Bladder
318 Autonomic Innervation of Kidneys and Upper Ureters: Schema
319 Autonomic Nerves of Suprarenal Glands: Dissection and Schema
320 Arteries and Veins of Suprarenal Glands in Situ

Sectional Anatomy

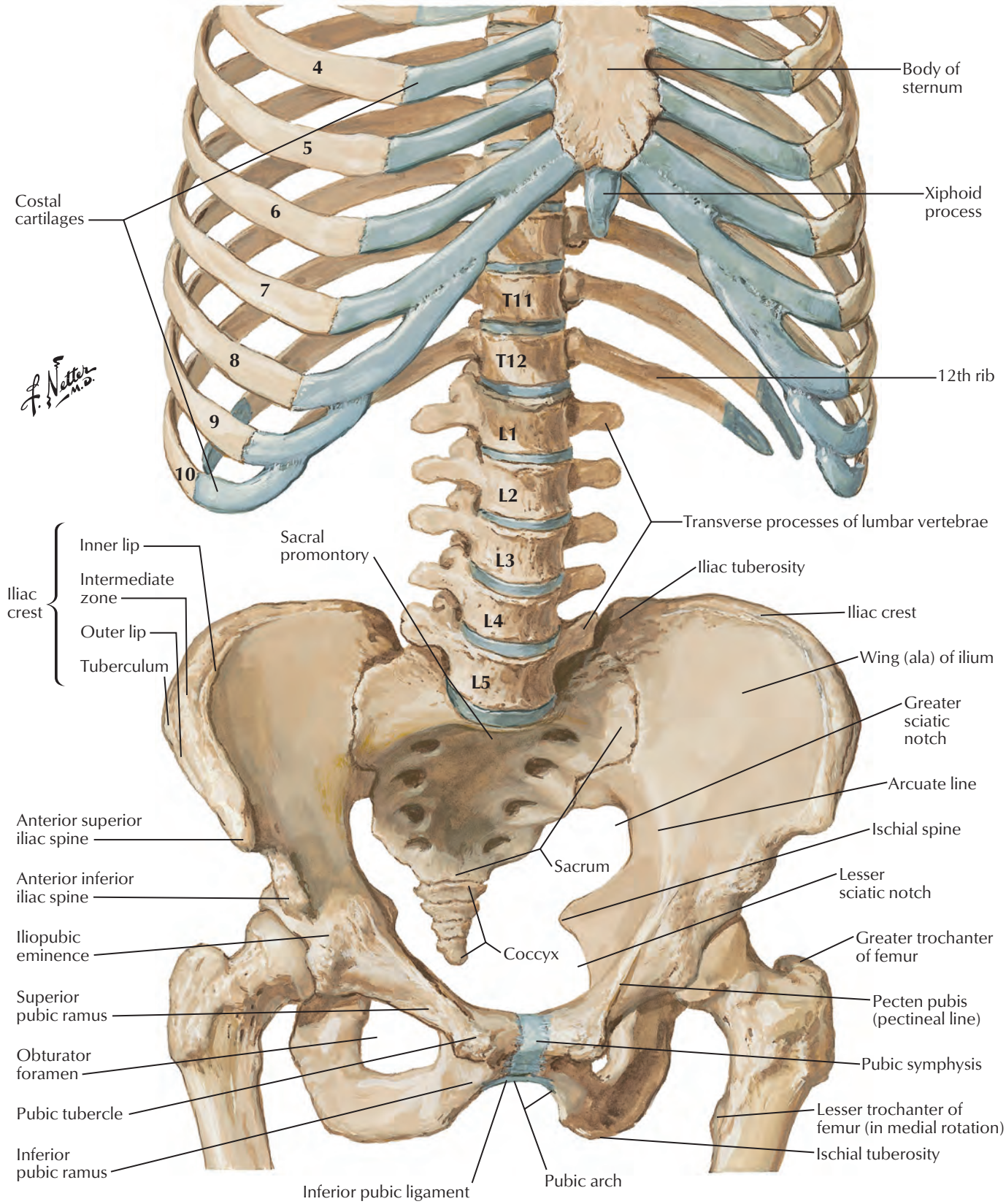
Plates 321–328

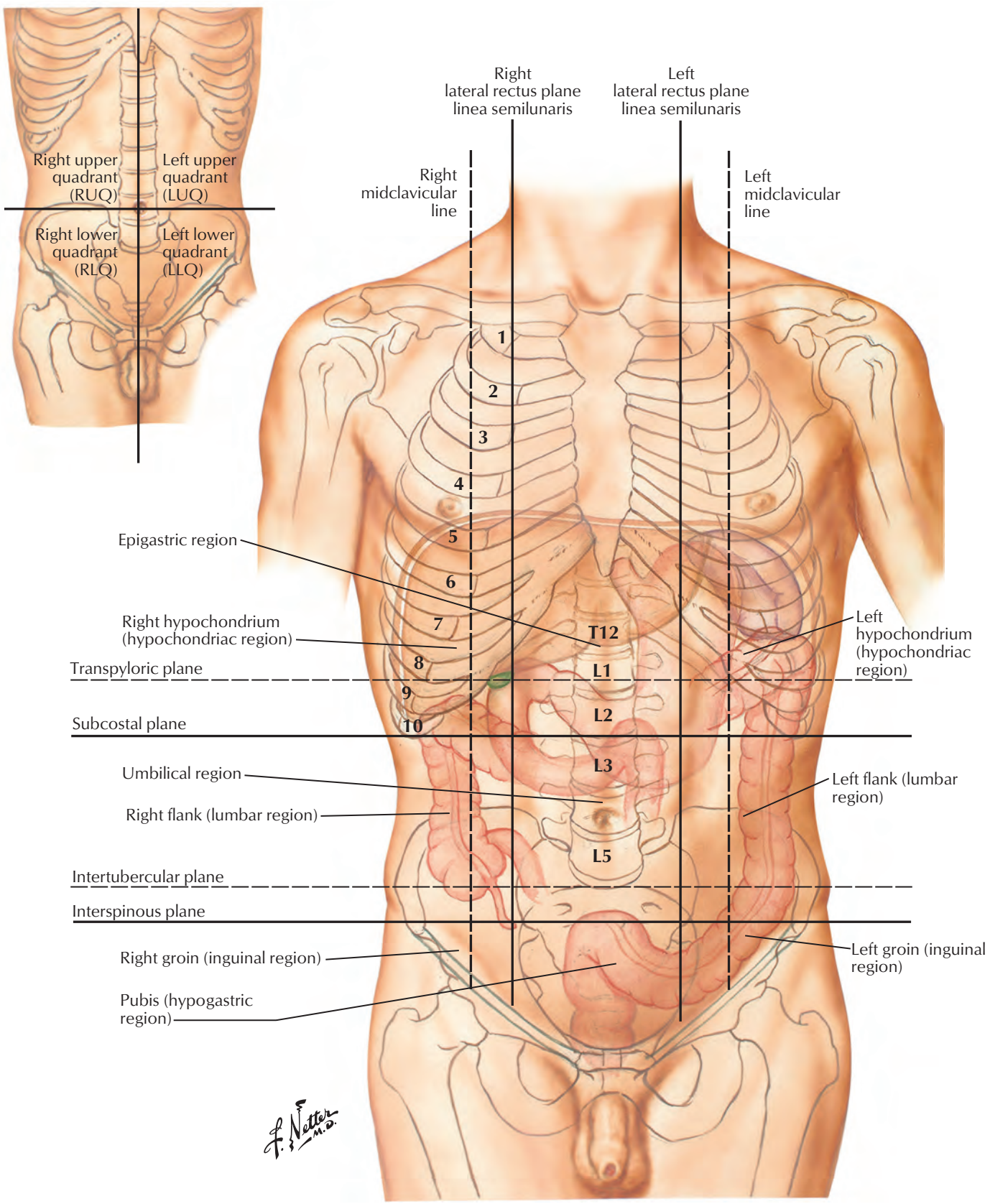
321 Abdominal Wall and Viscera: Paramedian (Parasagittal) Section
322 Abdominal Scans: Axial CT Images
323 Abdominal Scans: Axial CT Images (continued)
324 Cross Section at T10, Esophagogastric Junction
325 Cross Section at T12, Inferior to Xiphoid
326 Cross Section at T12–L1, Intervertebral Disc
327 Cross Section at L1–2, Intervertebral Disc
328 Cross Section at L3–4

Muscle Table


Sternum
Body
Xiphoid
process
Pectoralis
major muscle
Serratus
anterior
muscle
Tendinous
intersection
Rectus
abdominis
muscle
External
oblique
muscle
Linea alba
Linea semilunaris
Umbilicus
Iliac crest
Anterior superior
iliac spine
Superficial
circumflex iliac vein
Superficial
epigastric veins
Pubic symphysis
Inguinal
ligament
Pubic tubercle
C. Machado M.D.

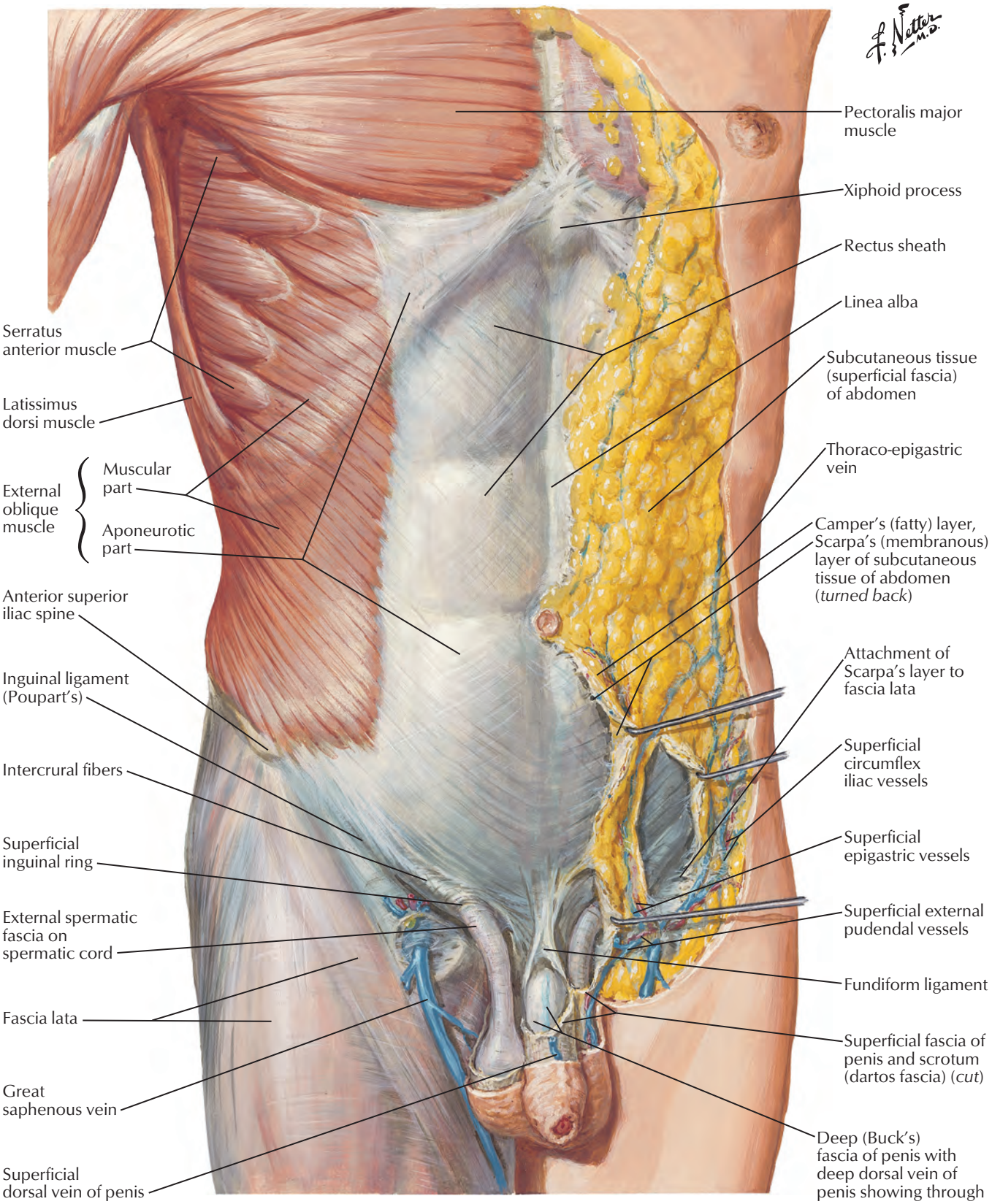
See also **Plates 183, 332**

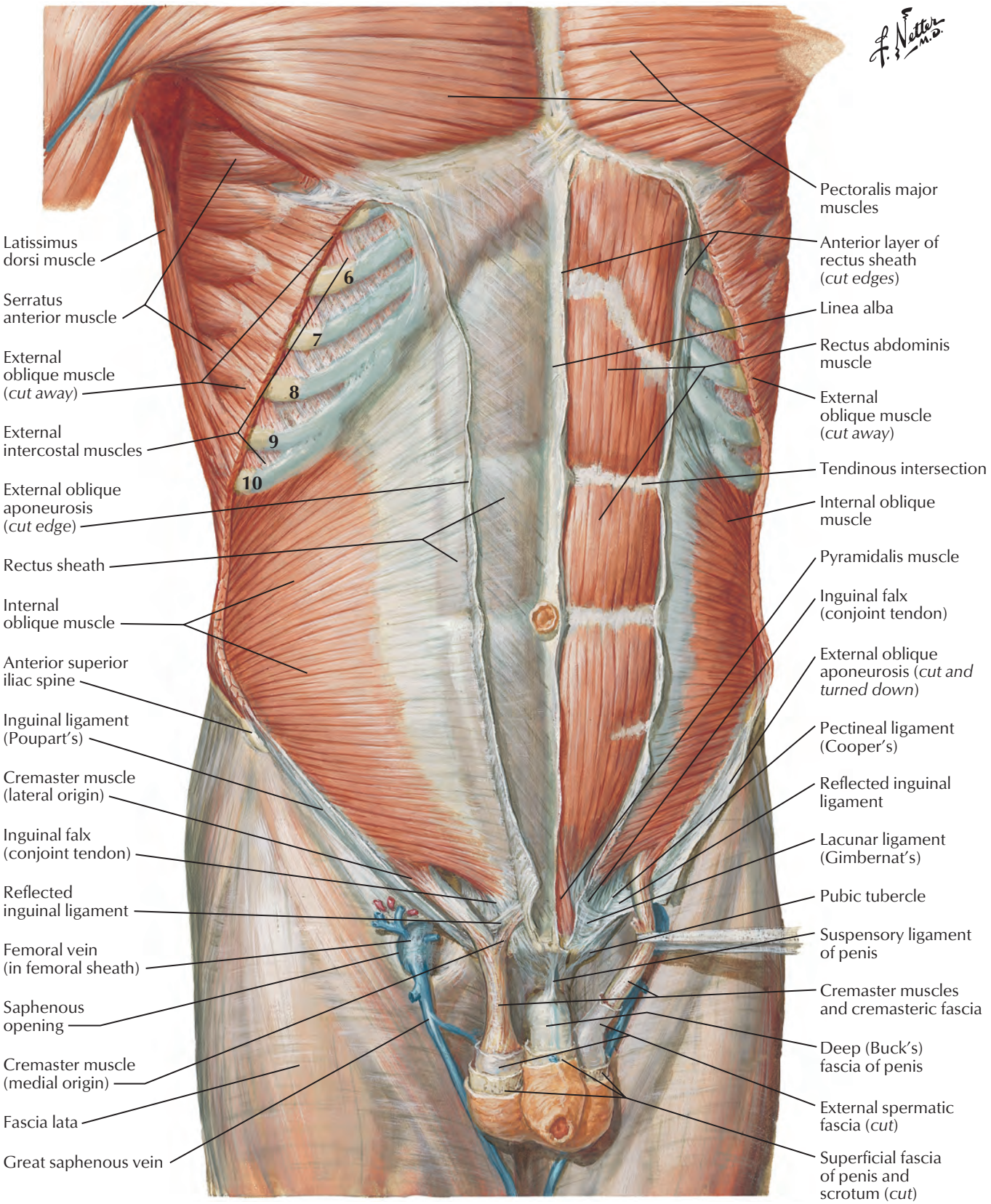



Right upper quadrant (RUQ)
Left upper quadrant (LUQ)
Right lower quadrant (RLQ)
Left lower quadrant (LLQ)
Right lateral rectus plane linea semilunaris
Left lateral rectus plane linea semilunaris
Right midclavicular line
Left midclavicular line
1
2
3
4
5
6
7
8
9
10
T12
L1
L2
L3
L5
Epigastric region
Right hypochondrium (hypochondriac region)
Left hypochondrium (hypochondriac region)
Transpyloric plane
Subcostal plane
Umbilical region
Right flank (lumbar region)
Left flank (lumbar region)
Intertubercular plane
Interspinous plane
Right groin (inguinal region)
Left groin (inguinal region)
Pubis (hypogastric region)
F. Netter M.D.

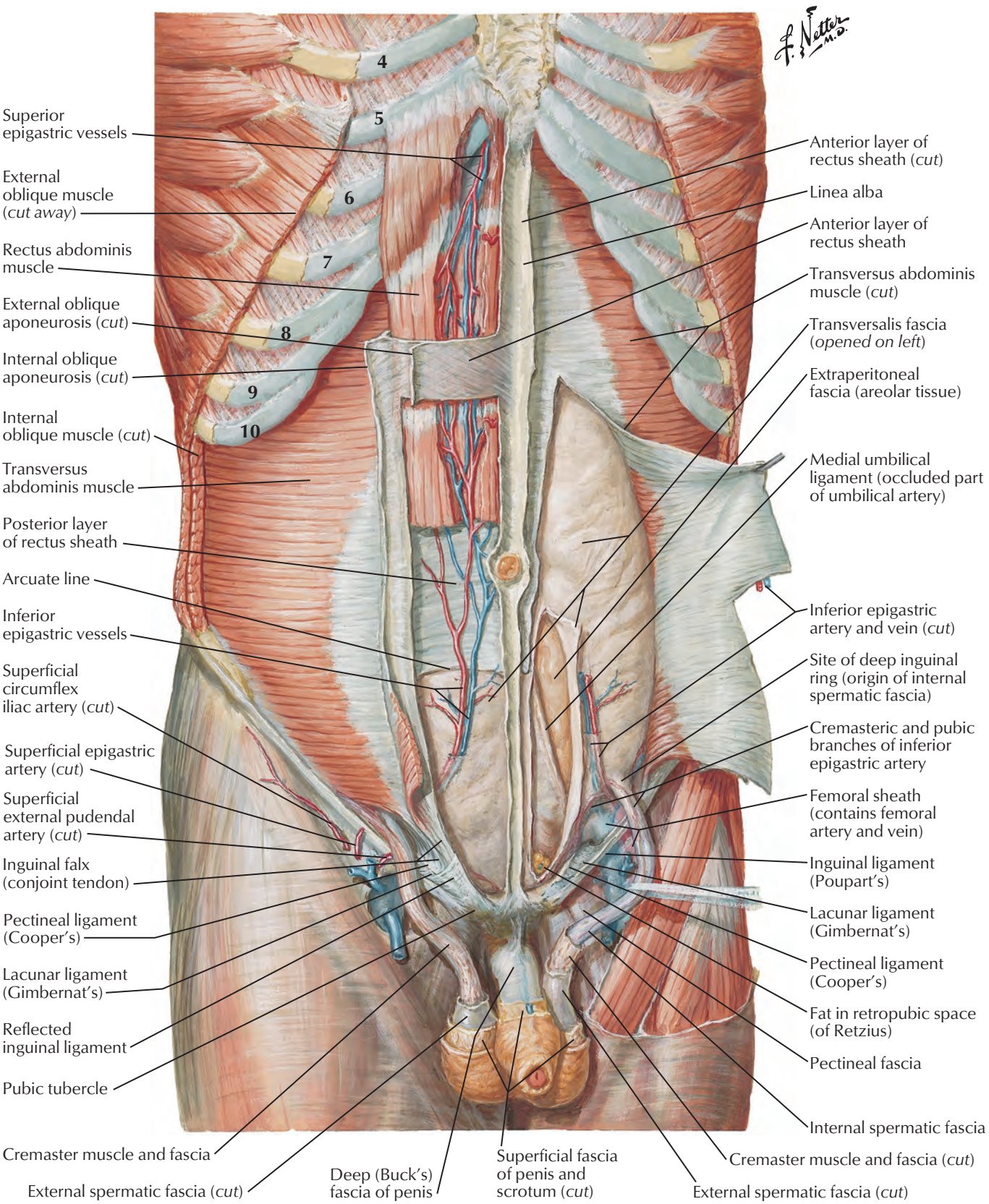
Anterior Abdominal Wall: Superficial Dissection

See also Plates 252, 329

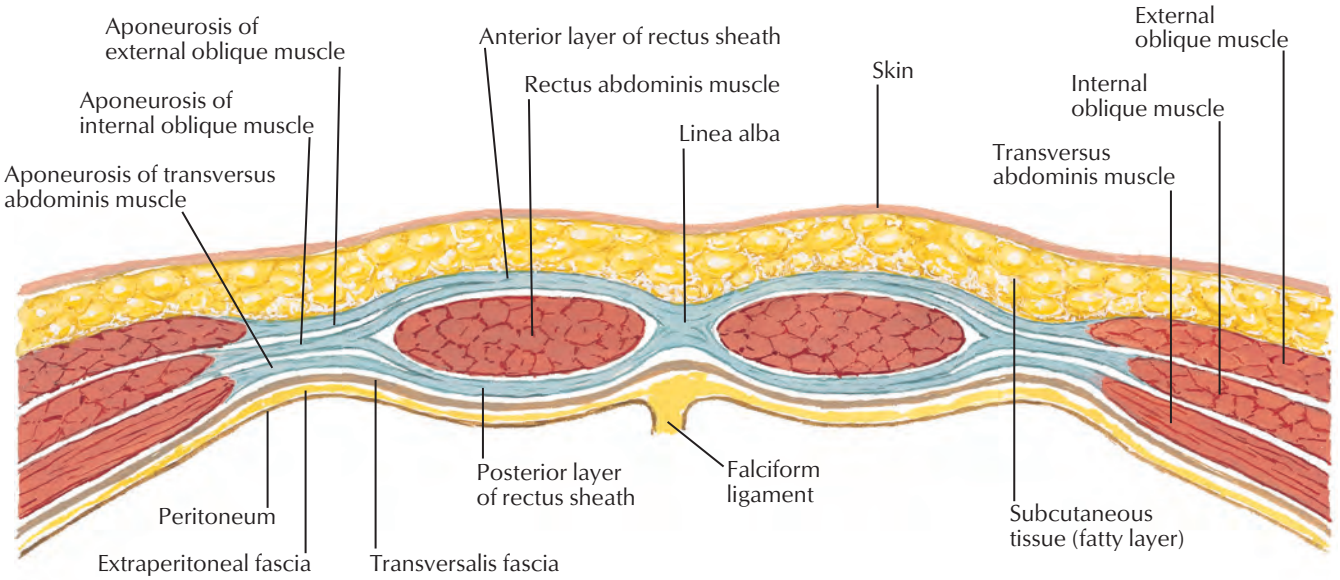



Latissimus dorsi muscle
Serratus anterior muscle
External oblique muscle (*cut away*)
External intercostal muscles
External oblique aponeurosis (*cut edge*)
Rectus sheath
Internal oblique muscle
Anterior superior iliac spine
Inguinal ligament (Poupart's)
Cremaster muscle (lateral origin)
Inguinal falx (conjoint tendon)
Reflected inguinal ligament
Femoral vein (in femoral sheath)
Saphenous opening
Cremaster muscle (medial origin)
Fascia lata
Great saphenous vein
6
7
8
9
10
Pectoralis major muscles
Anterior layer of rectus sheath (*cut edges*)
Linea alba
Rectus abdominis muscle
External oblique muscle (*cut away*)
Tendinous intersection
Internal oblique muscle
Pyramidalis muscle
Inguinal falx (conjoint tendon)
External oblique aponeurosis (*cut and turned down*)
Pectineal ligament (Cooper's)
Reflected inguinal ligament
Lacunar ligament (Gimbernat's)
Pubic tubercle
Suspensory ligament of penis
Cremaster muscles and cremasteric fascia
Deep (Buck's) fascia of penis
External spermatic fascia (*cut*)
Superficial fascia of penis and scrotum (*cut*)

See also **Plates 186, 251**

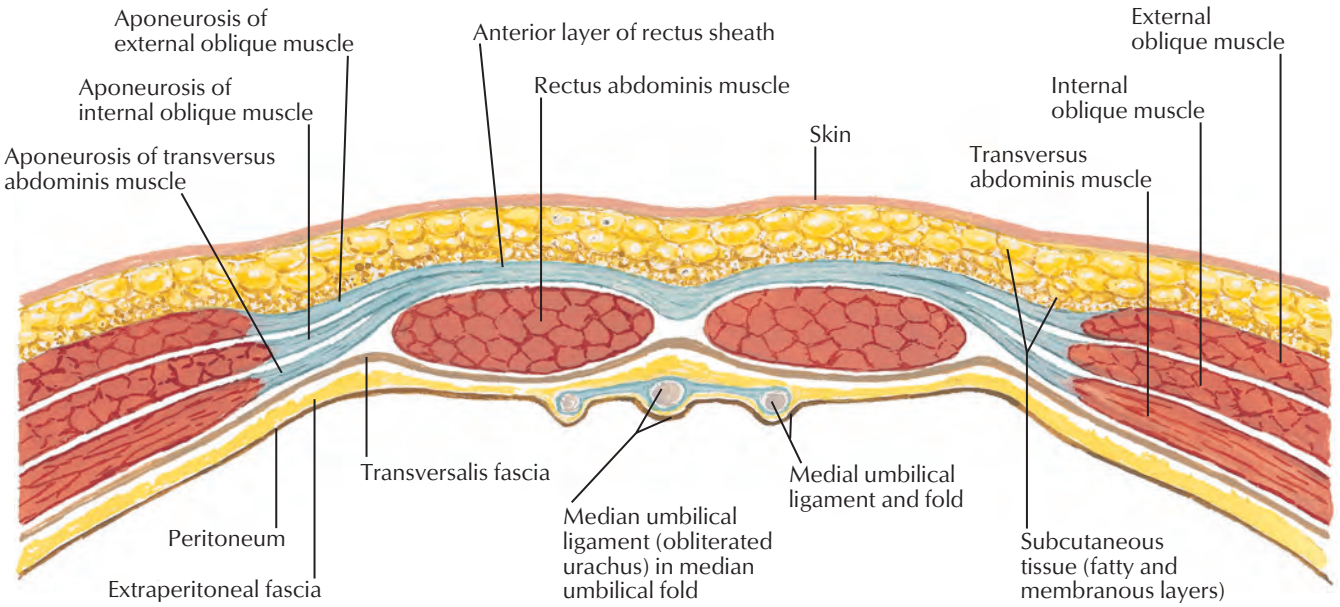


Section above arcuate line



Aponeurosis of internal oblique muscle splits to form anterior and posterior layers of rectus sheath. Aponeurosis of external oblique muscle joins anterior layer of sheath; aponeurosis of transversus abdominis muscle joins posterior layer. Anterior and posterior layers of rectus sheath unite medially to form linea alba.

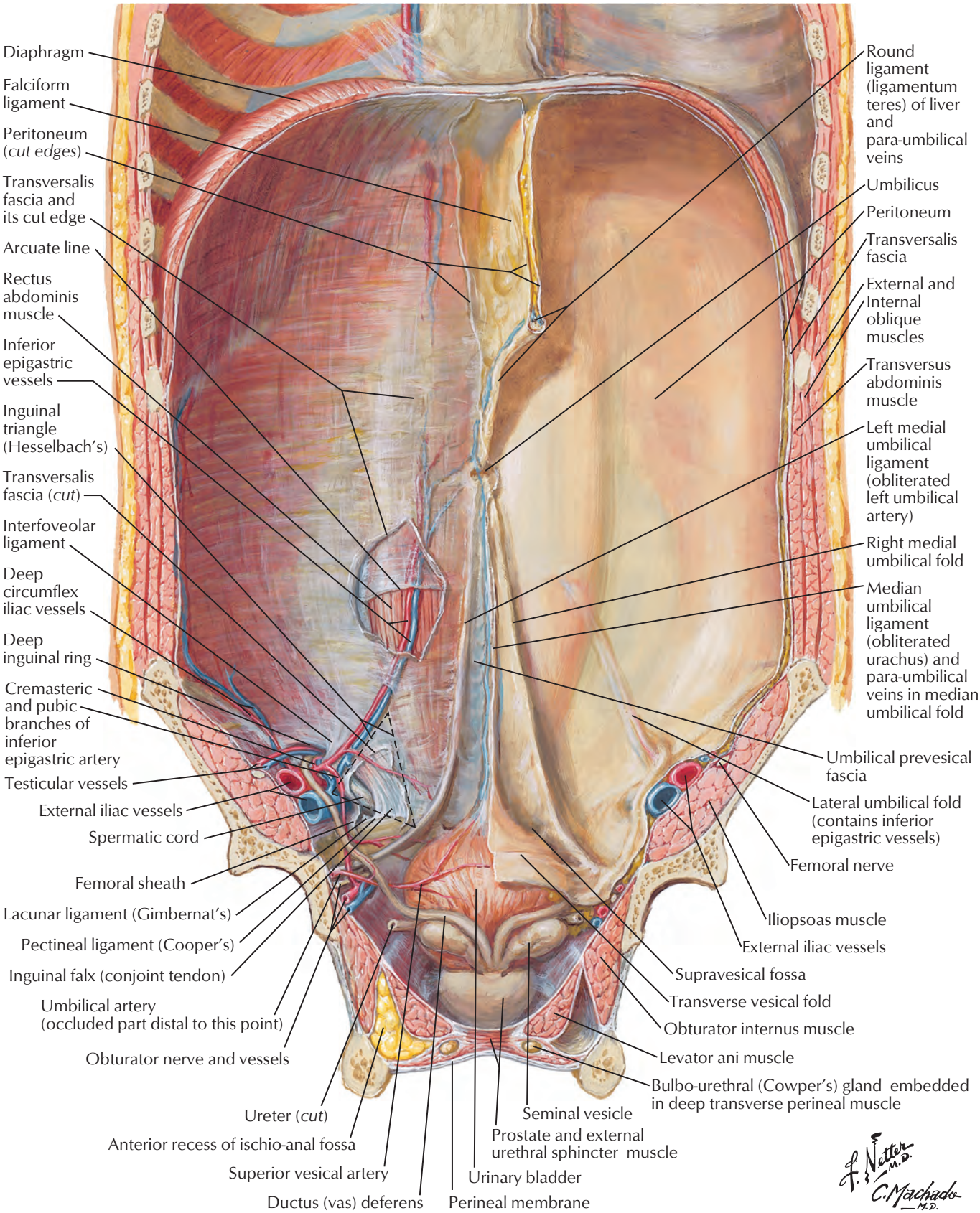
Section below arcuate line

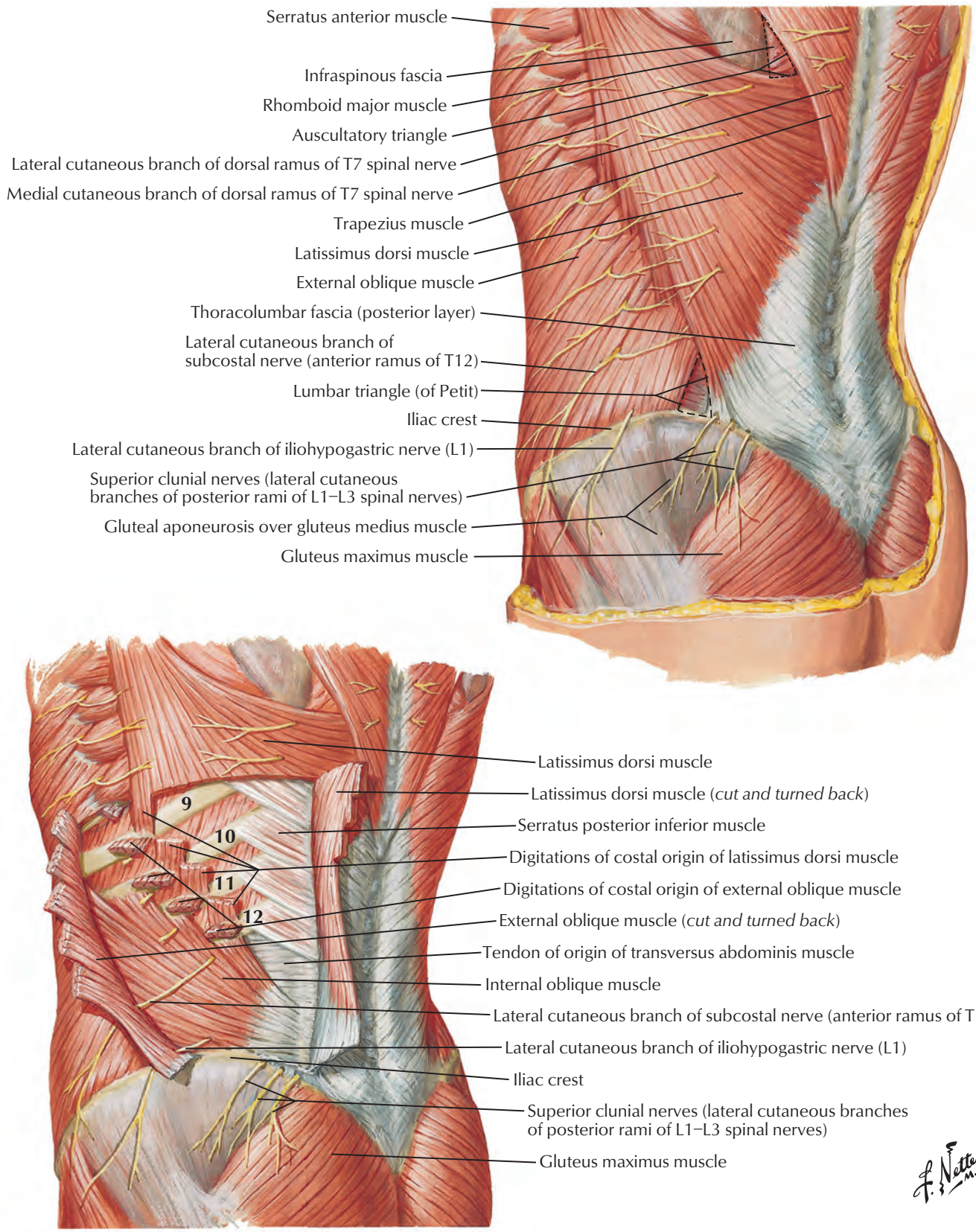


Aponeurosis of internal oblique muscle does not split at this level but passes completely anterior to rectus abdominis muscle and is fused there with both aponeurosis of external oblique muscle and that of transversus abdominis muscle. Thus, posterior wall of rectus sheath is absent below arcuate line, leaving only transversalis fascia.

Anterior Abdominal Wall: Internal View

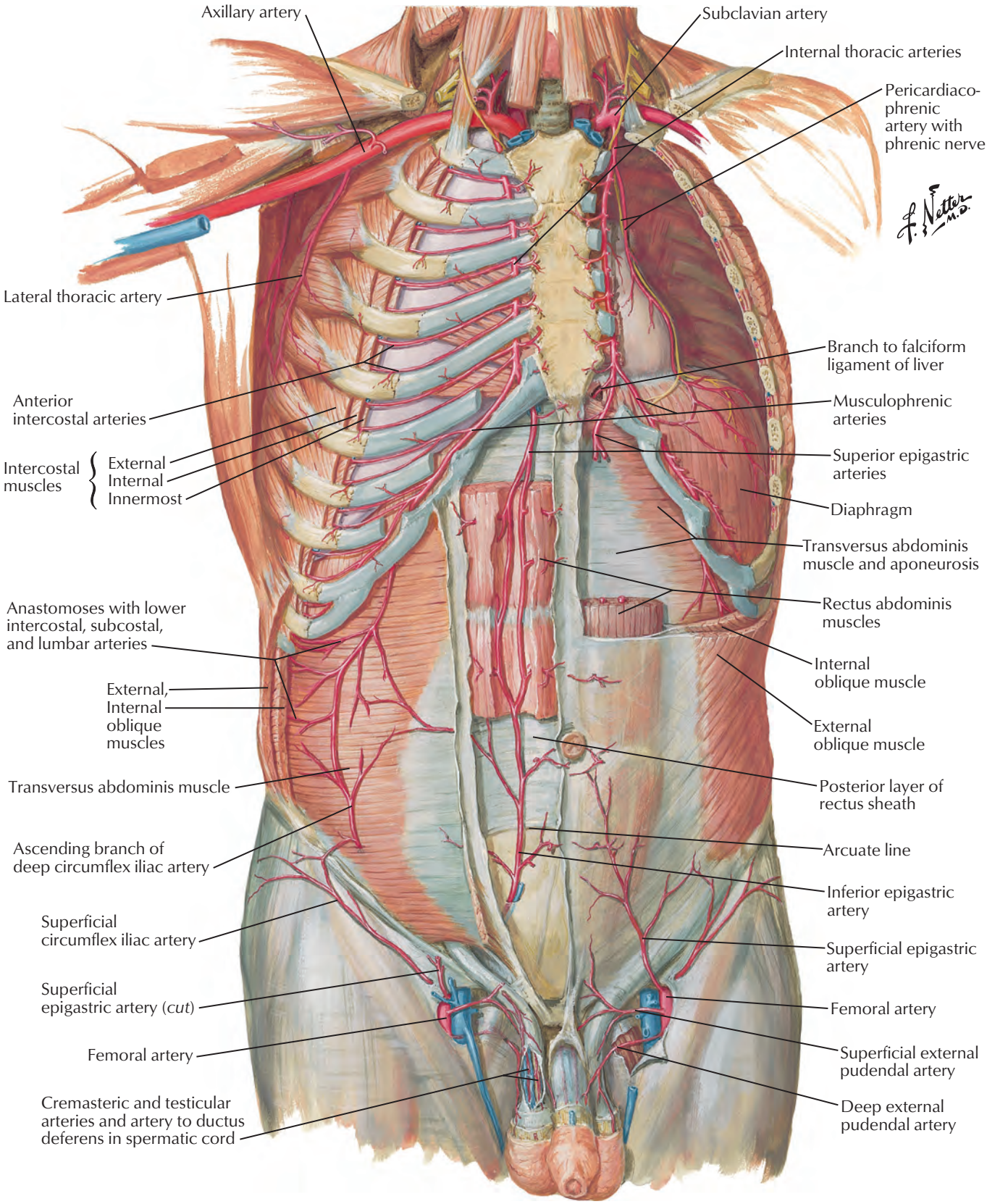
See also **Plates 362, 381**

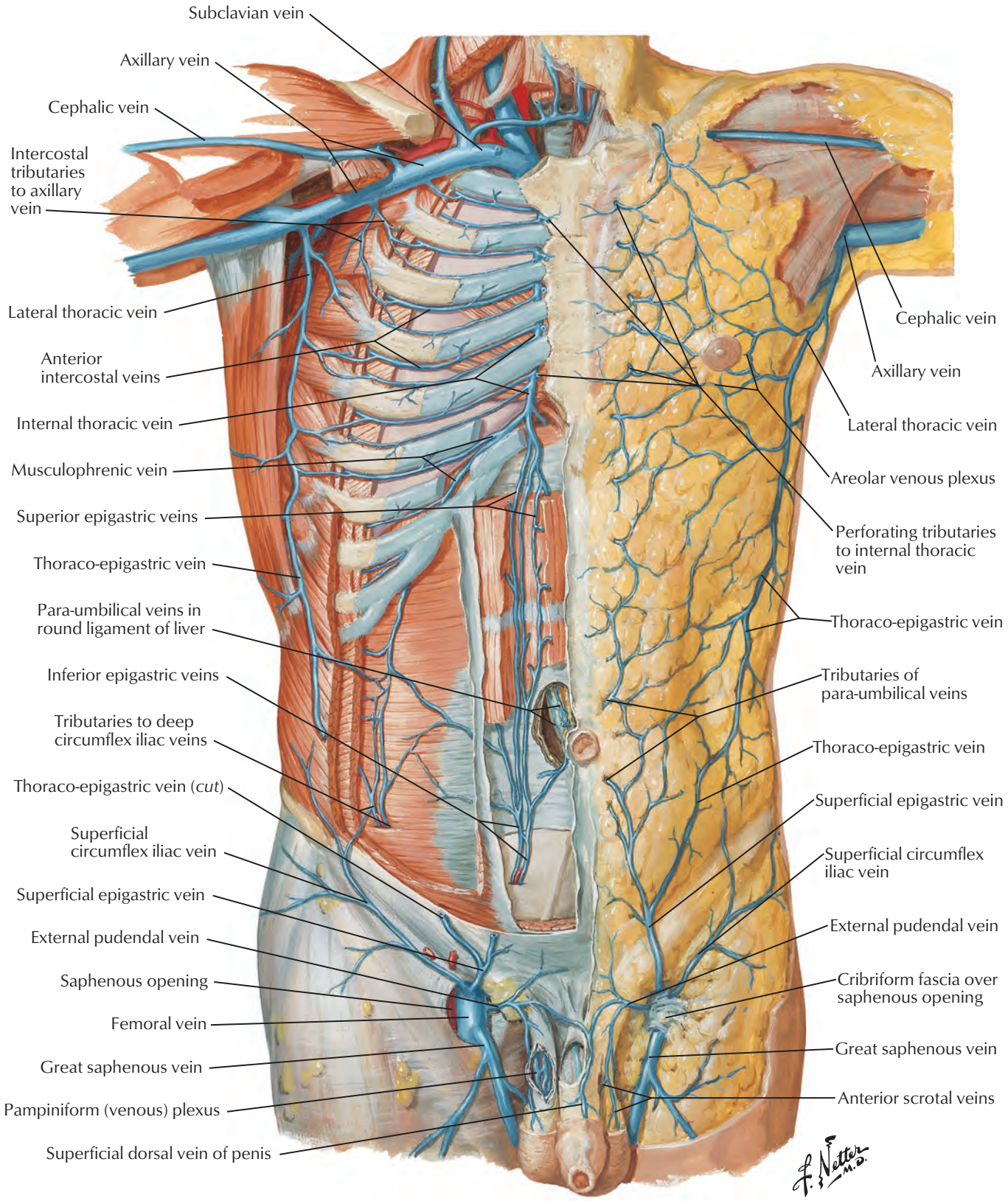



Serratus anterior muscle
Infraspinous fascia
Rhomboid major muscle
Auscultatory triangle
Lateral cutaneous branch of dorsal ramus of T7 spinal nerve
Medial cutaneous branch of dorsal ramus of T7 spinal nerve
Trapezius muscle
Latissimus dorsi muscle
External oblique muscle
Thoracolumbar fascia (posterior layer)
Lateral cutaneous branch of subcostal nerve (anterior ramus of T12)
Lumbar triangle (of Petit)
Iliac crest
Lateral cutaneous branch of iliohypogastric nerve (L1)
Superior clunial nerves (lateral cutaneous branches of posterior rami of L1–L3 spinal nerves)
Gluteal aponeurosis over gluteus medius muscle
Gluteus maximus muscle
9
10
11
12
Latissimus dorsi muscle
Latissimus dorsi muscle (cut and turned back)
Serratus posterior inferior muscle
Digitations of costal origin of latissimus dorsi muscle
Digitations of costal origin of external oblique muscle
External oblique muscle (cut and turned back)
Tendon of origin of transversus abdominis muscle
Internal oblique muscle
Lateral cutaneous branch of subcostal nerve (anterior ramus of T12)
Lateral cutaneous branch of iliohypogastric nerve (L1)
Iliac crest
Superior clunial nerves (lateral cutaneous branches of posterior rami of L1–L3 spinal nerves)
Gluteus maximus muscle
F. Netter M.D.

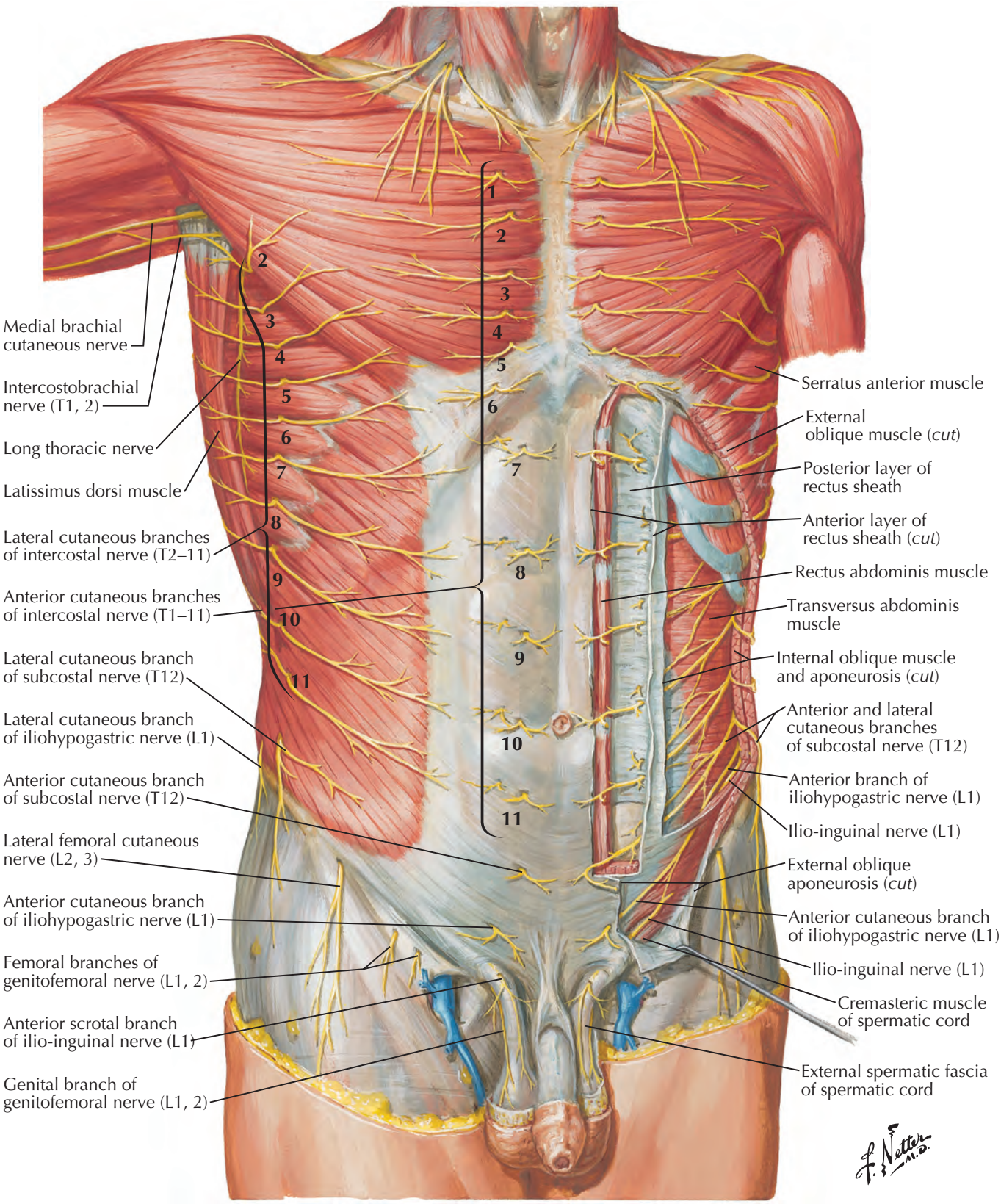
Arteries of Anterior Abdominal Wall

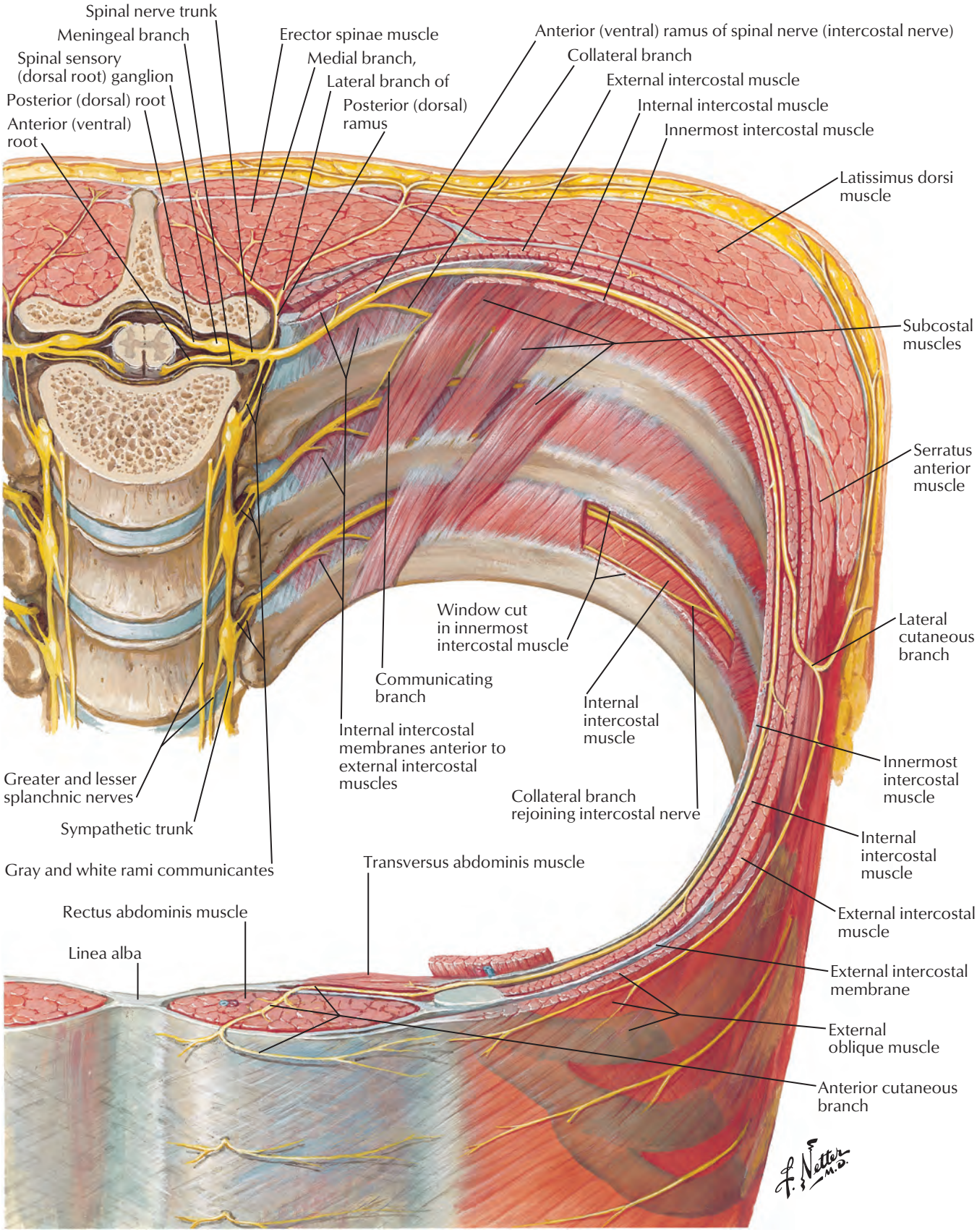
See also Plate 247




Subclavian vein
Axillary vein
Cephalic vein
Intercostal tributaries to axillary vein
Lateral thoracic vein
Anterior intercostal veins
Internal thoracic vein
Musculophrenic vein
Superior epigastric veins
Thoraco-epigastric vein
Para-umbilical veins in round ligament of liver
Inferior epigastric veins
Tributaries to deep circumflex iliac veins
Thoraco-epigastric vein (cut)
Superficial circumflex iliac vein
Superficial epigastric vein
External pudendal vein
Saphenous opening
Femoral vein
Great saphenous vein
Pampiniform (venous) plexus
Superficial dorsal vein of penis
Cephalic vein
Axillary vein
Lateral thoracic vein
Areolar venous plexus
Perforating tributaries to internal thoracic vein
Thoraco-epigastric vein
Tributaries of para-umbilical veins
Thoraco-epigastric vein
Superficial epigastric vein
Superficial circumflex iliac vein
External pudendal vein
Cribriform fascia over saphenous opening
Great saphenous vein
Anterior scrotal veins
F. Netter M.D.

See also **Plates 177, 185, 254**




Spinal nerve trunk
Meningeal branch
Spinal sensory (dorsal root) ganglion
Posterior (dorsal) root
Anterior (ventral) root
Erector spinae muscle
Medial branch,
Lateral branch of Posterior (dorsal) ramus
Anterior (ventral) ramus of spinal nerve (intercostal nerve)
Collateral branch
External intercostal muscle
Internal intercostal muscle
Innermost intercostal muscle
Latissimus dorsi muscle
Subcostal muscles
Serratus anterior muscle
Lateral cutaneous branch
Window cut in innermost intercostal muscle
Communicating branch
Internal intercostal membranes anterior to external intercostal muscles
Internal intercostal muscle
Innermost intercostal muscle
Collateral branch rejoining intercostal nerve
Greater and lesser splanchnic nerves
Sympathetic trunk
Gray and white rami communicantes
Transversus abdominis muscle
Internal intercostal muscle
External intercostal muscle
Rectus abdominis muscle
Linea alba
External intercostal membrane
External oblique muscle
Anterior cutaneous branch
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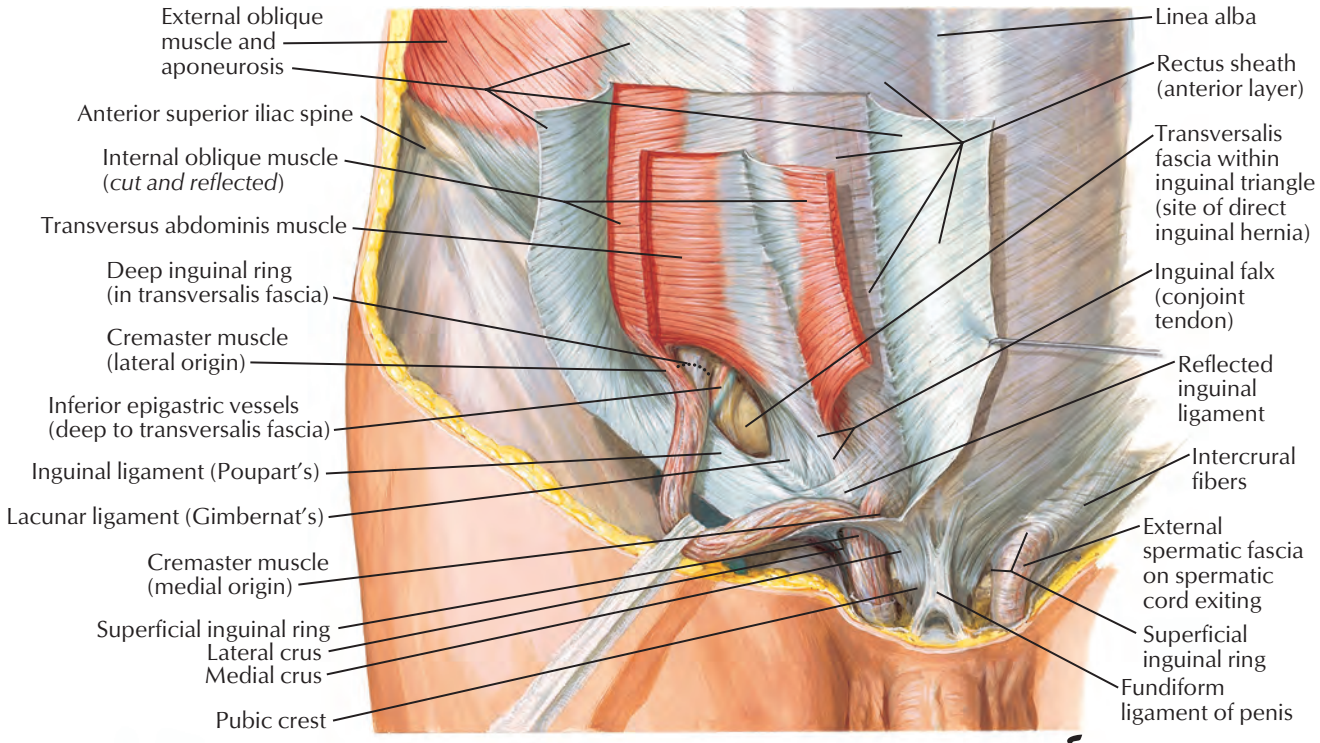
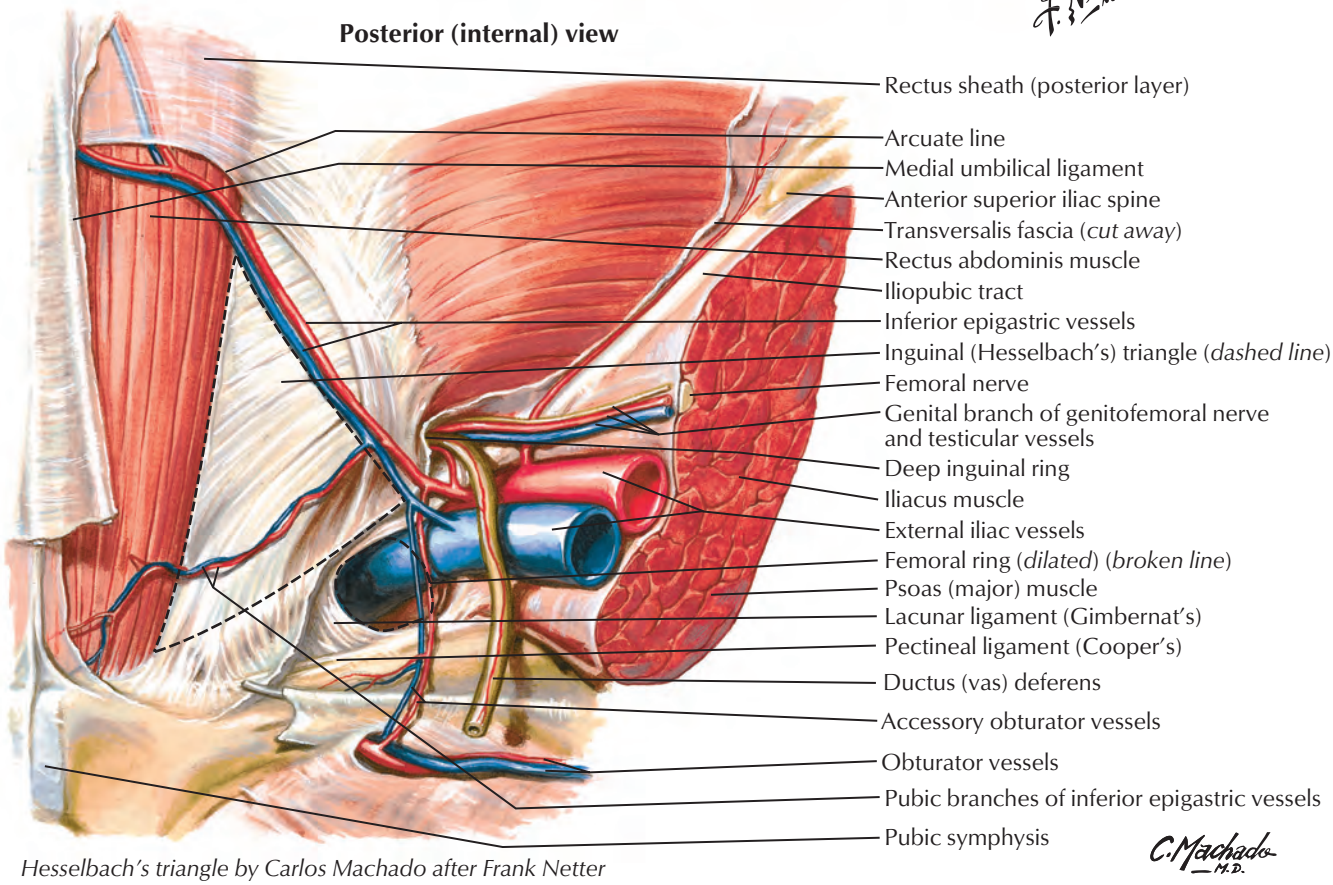
See also Plates 247, 249

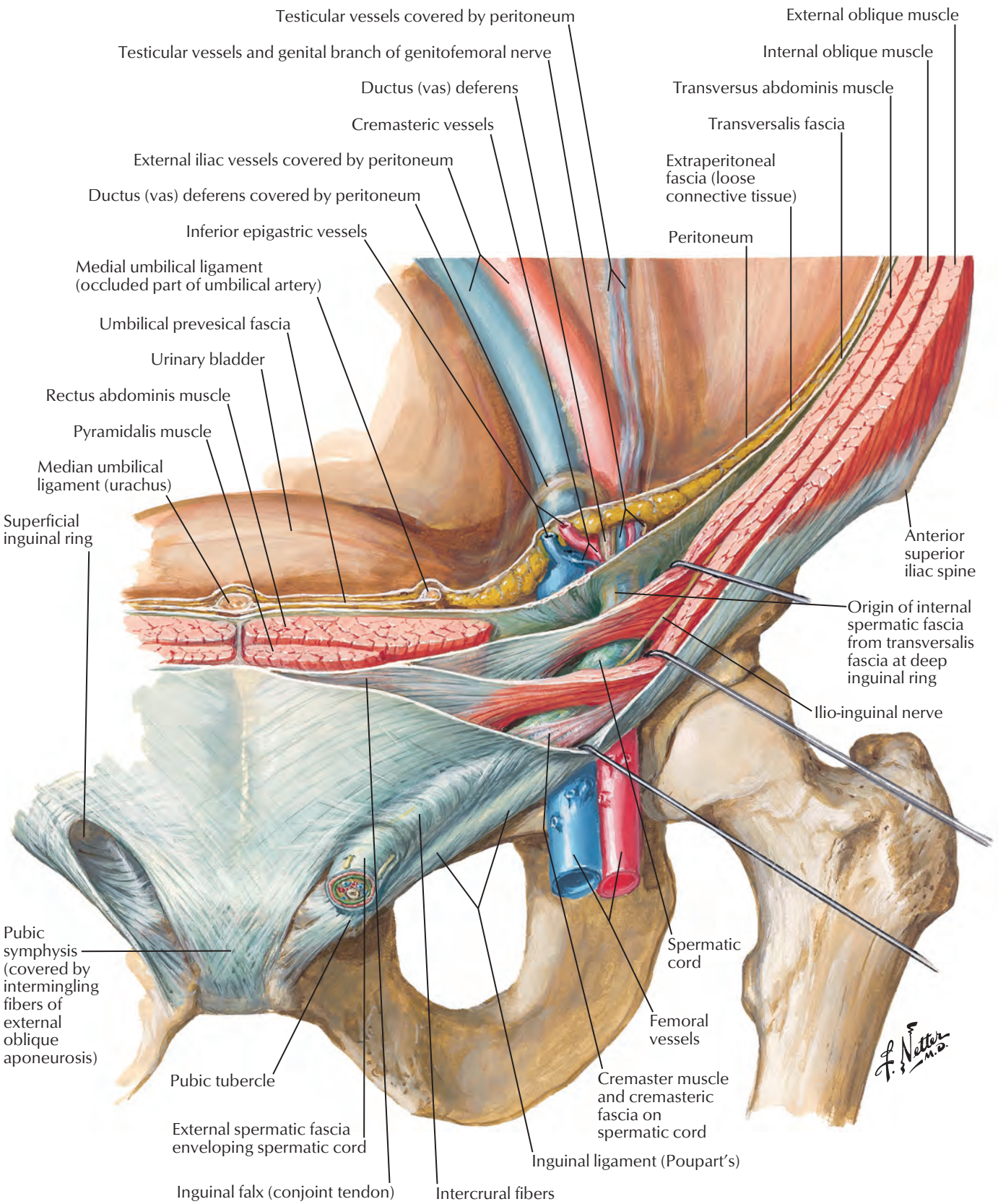


Anterior view

Posterior (internal) view



Hesselbach's triangle by Carlos Machado after Frank Netter


Testicular vessels covered by peritoneum
Testicular vessels and genital branch of genitofemoral nerve
Ductus (vas) deferens
Cremasteric vessels
External iliac vessels covered by peritoneum
Ductus (vas) deferens covered by peritoneum
Inferior epigastric vessels
Medial umbilical ligament (occluded part of umbilical artery)
Umbilical prevesical fascia
Urinary bladder
Rectus abdominis muscle
Pyramidalis muscle
Median umbilical ligament (urachus)
Superficial inguinal ring
Pubic symphysis (covered by intermingling fibers of external oblique aponeurosis)
Pubic tubercle
External spermatic fascia enveloping spermatic cord
Inguinal falx (conjoint tendon)
Intercrural fibers
Inguinal ligament (Poupart's)
Cremaster muscle and cremasteric fascia on spermatic cord
Femoral vessels
Spermatic cord
Origin of internal spermatic fascia from transversalis fascia at deep inguinal ring
Ilio-inguinal nerve
Anterior superior iliac spine
Peritoneum
Extraperitoneal fascia (loose connective tissue)
Transversalis fascia
Transversus abdominis muscle
Internal oblique muscle
External oblique muscle
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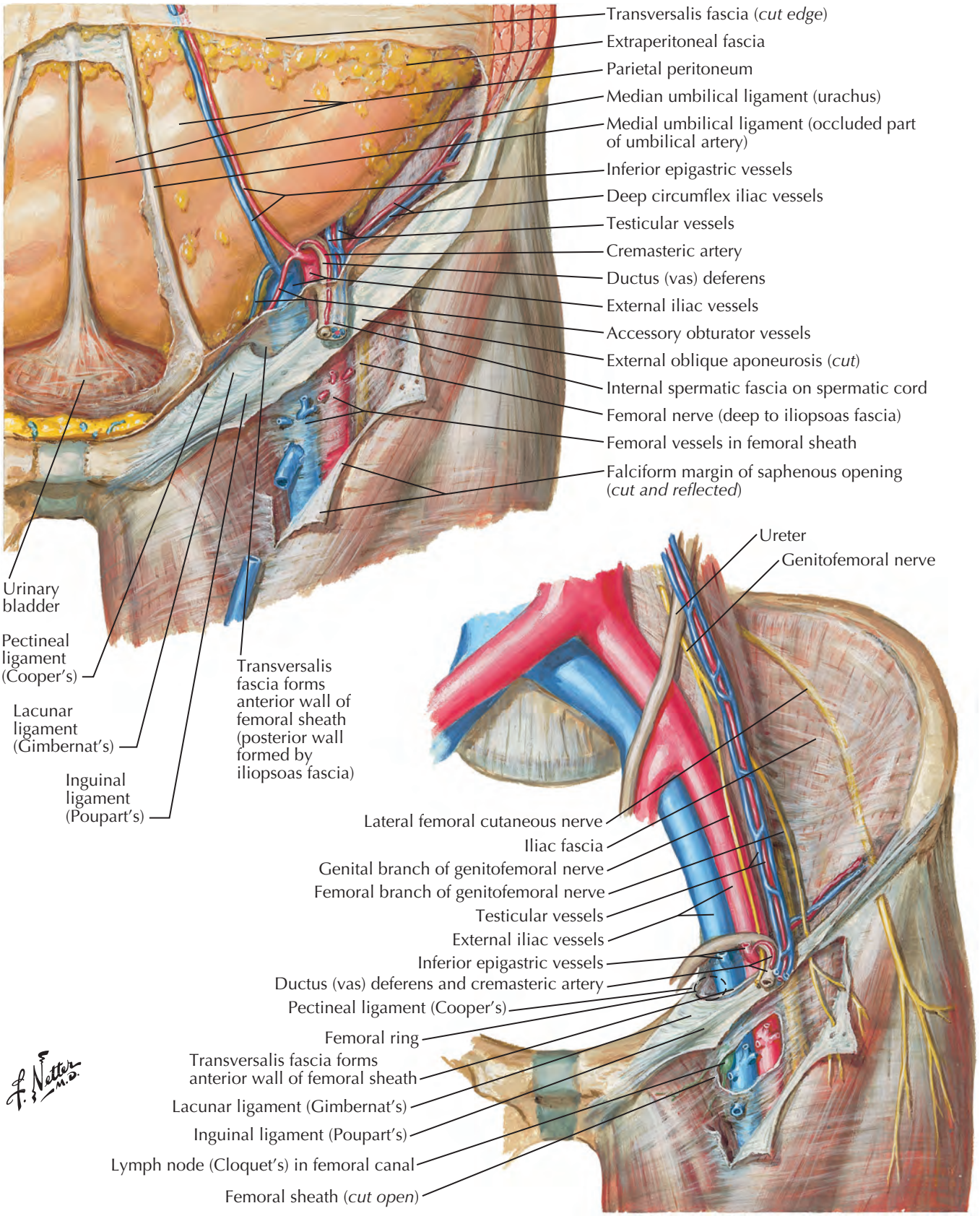
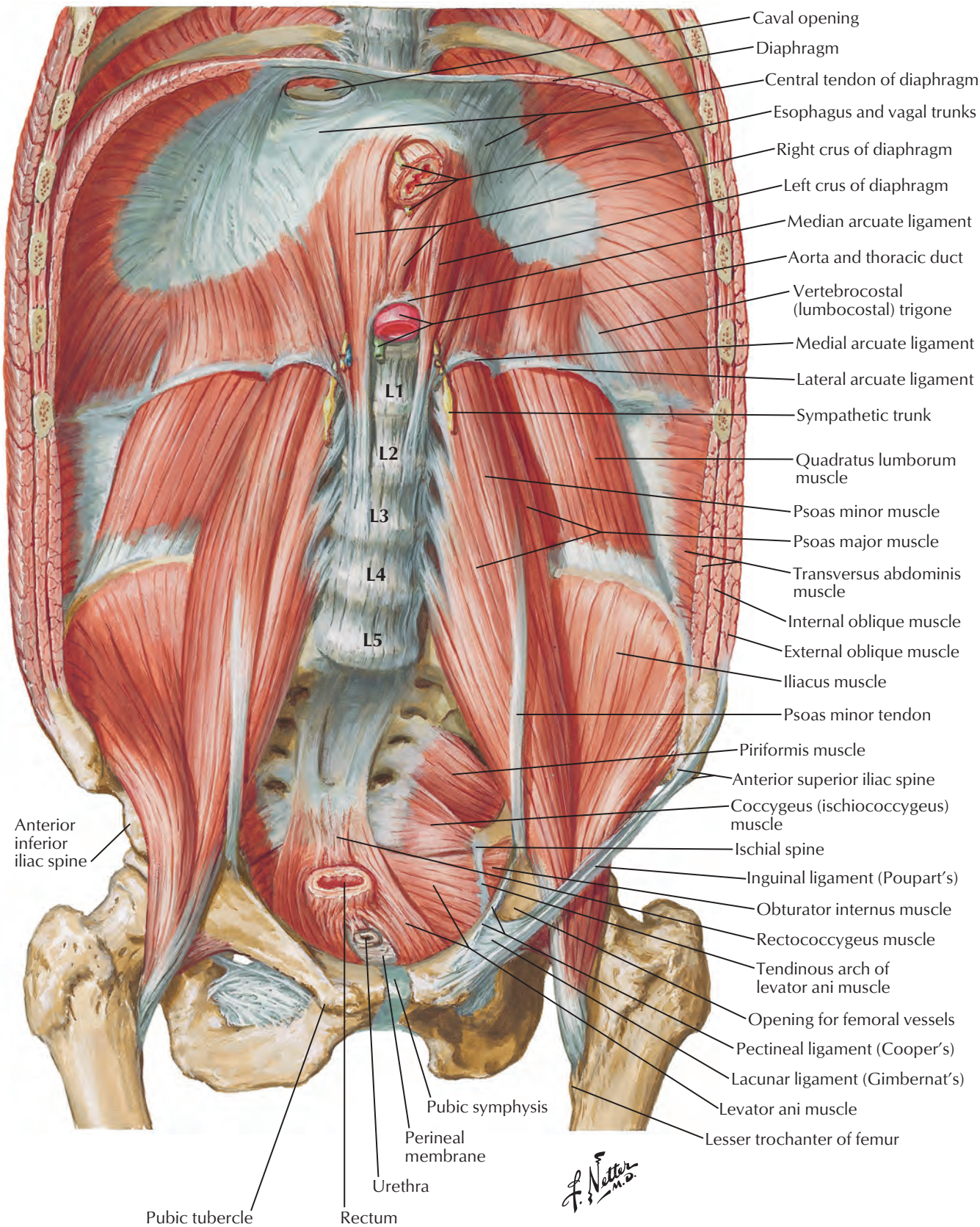
Femoral Sheath and Inguinal Canal

See also Plates 245, 247, 249




Caval opening
Diaphragm
Central tendon of diaphragm
Esophagus and vagal trunks
Right crus of diaphragm
Left crus of diaphragm
Median arcuate ligament
Aorta and thoracic duct
Vertebrocostal (lumbocostal) trigone
Medial arcuate ligament
Lateral arcuate ligament
Sympathetic trunk
Quadratus lumborum muscle
Psoas minor muscle
Psoas major muscle
Transversus abdominis muscle
Internal oblique muscle
External oblique muscle
Iliacus muscle
Psoas minor tendon
Piriformis muscle
Anterior superior iliac spine
Coccygeus (ischiococcygeus) muscle
Ischial spine
Inguinal ligament (Poupart's)
Obturator internus muscle
Rectococcygeus muscle
Tendinous arch of levator ani muscle
Opening for femoral vessels
Pectineal ligament (Cooper's)
Lacunar ligament (Gimbernat's)
Levator ani muscle
Lesser trochanter of femur
L1
L2
L3
L4
L5
Anterior inferior iliac spine
Pubic symphysis
Perineal membrane
Urethra
Pubic tubercle
Rectum
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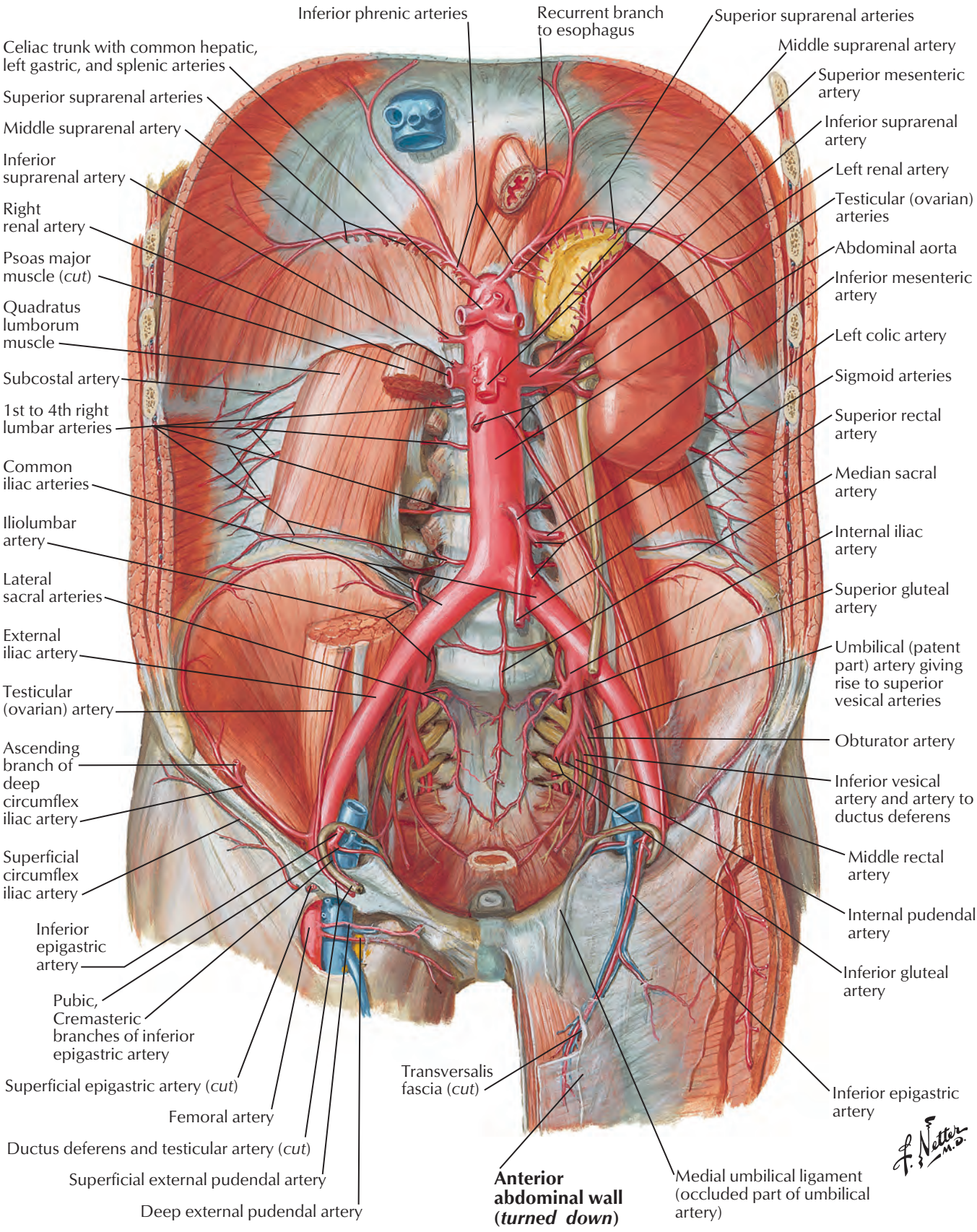
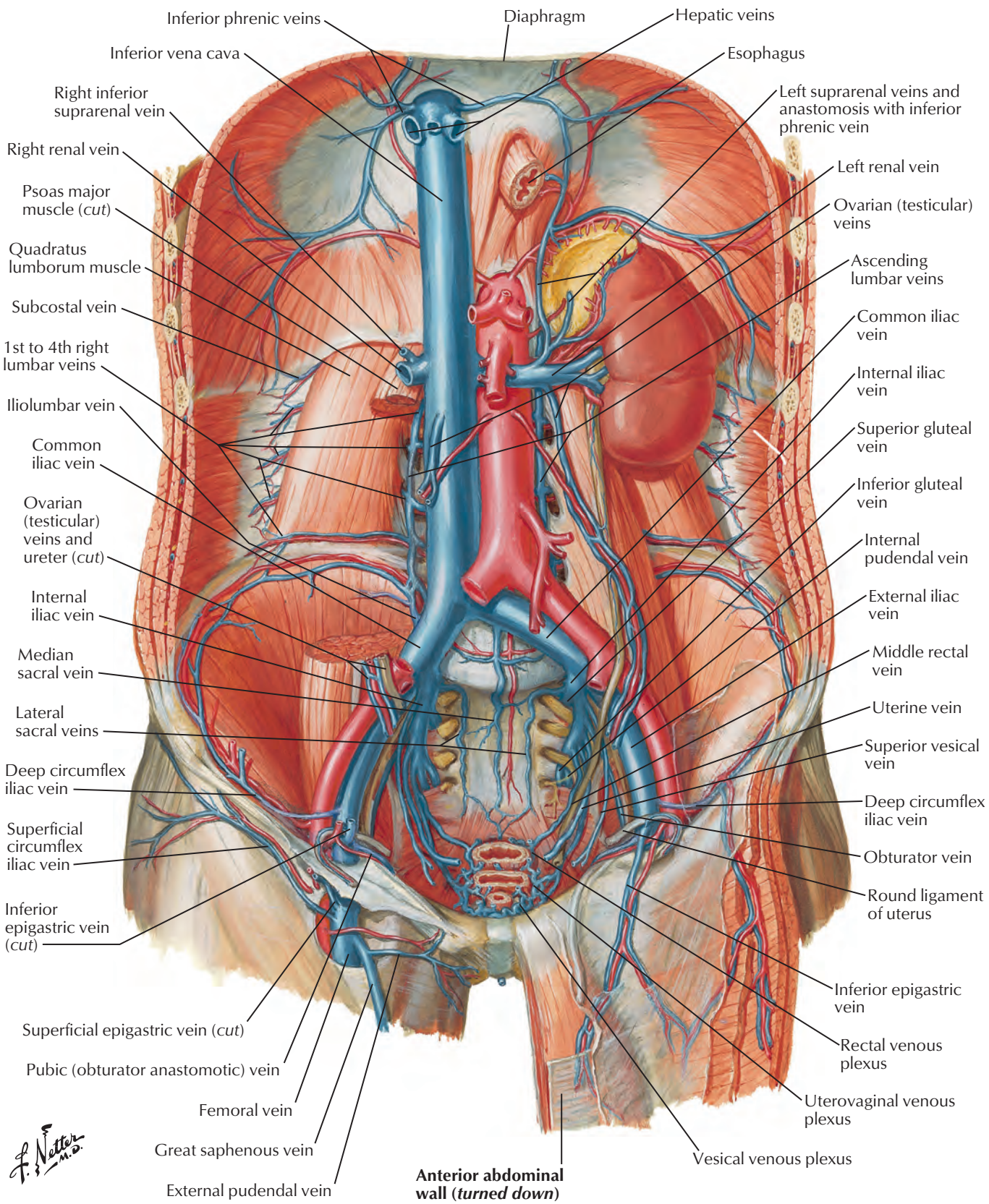
Arteries of Posterior Abdominal Wall

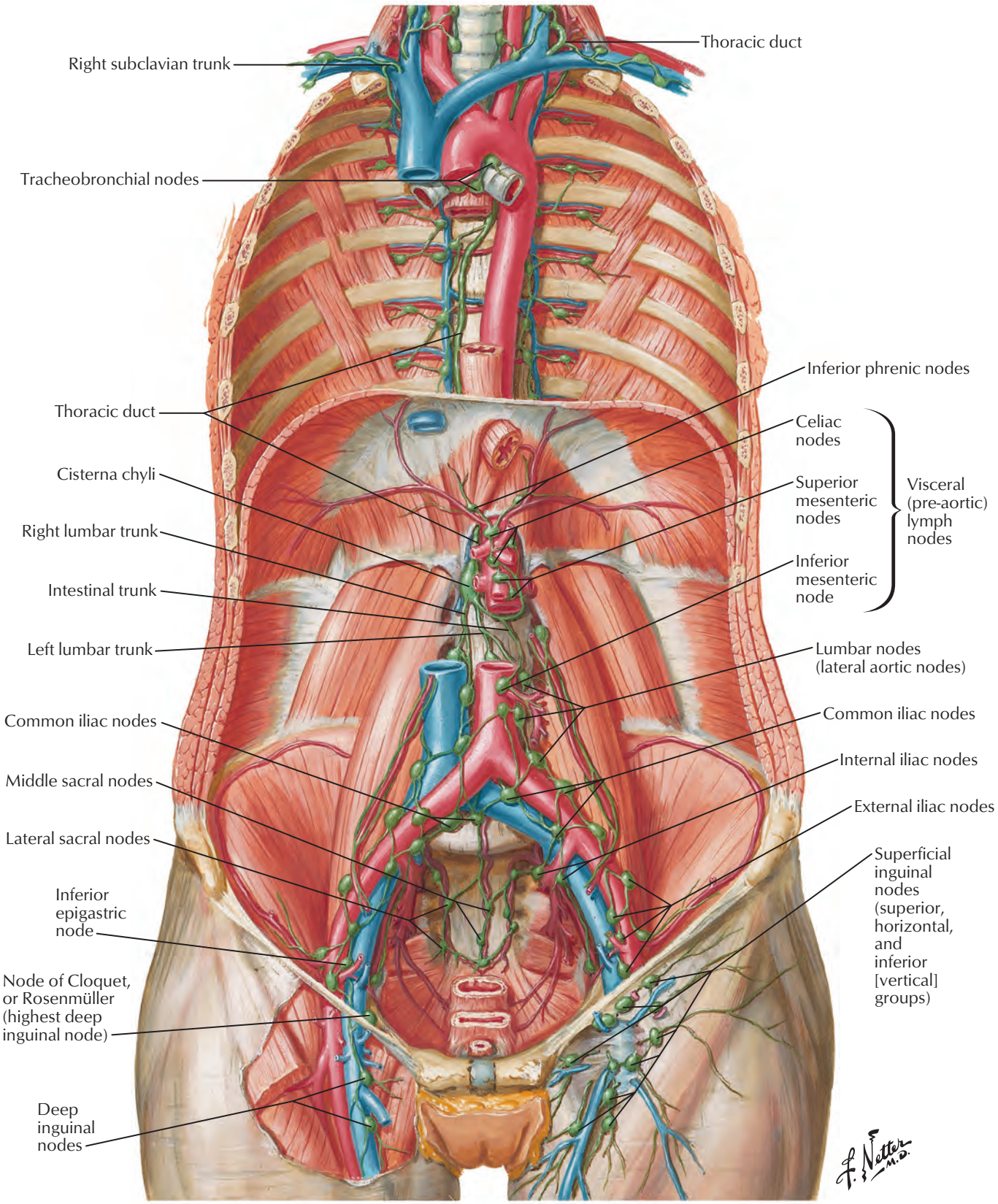
See also **Plates 192, 379, 381**

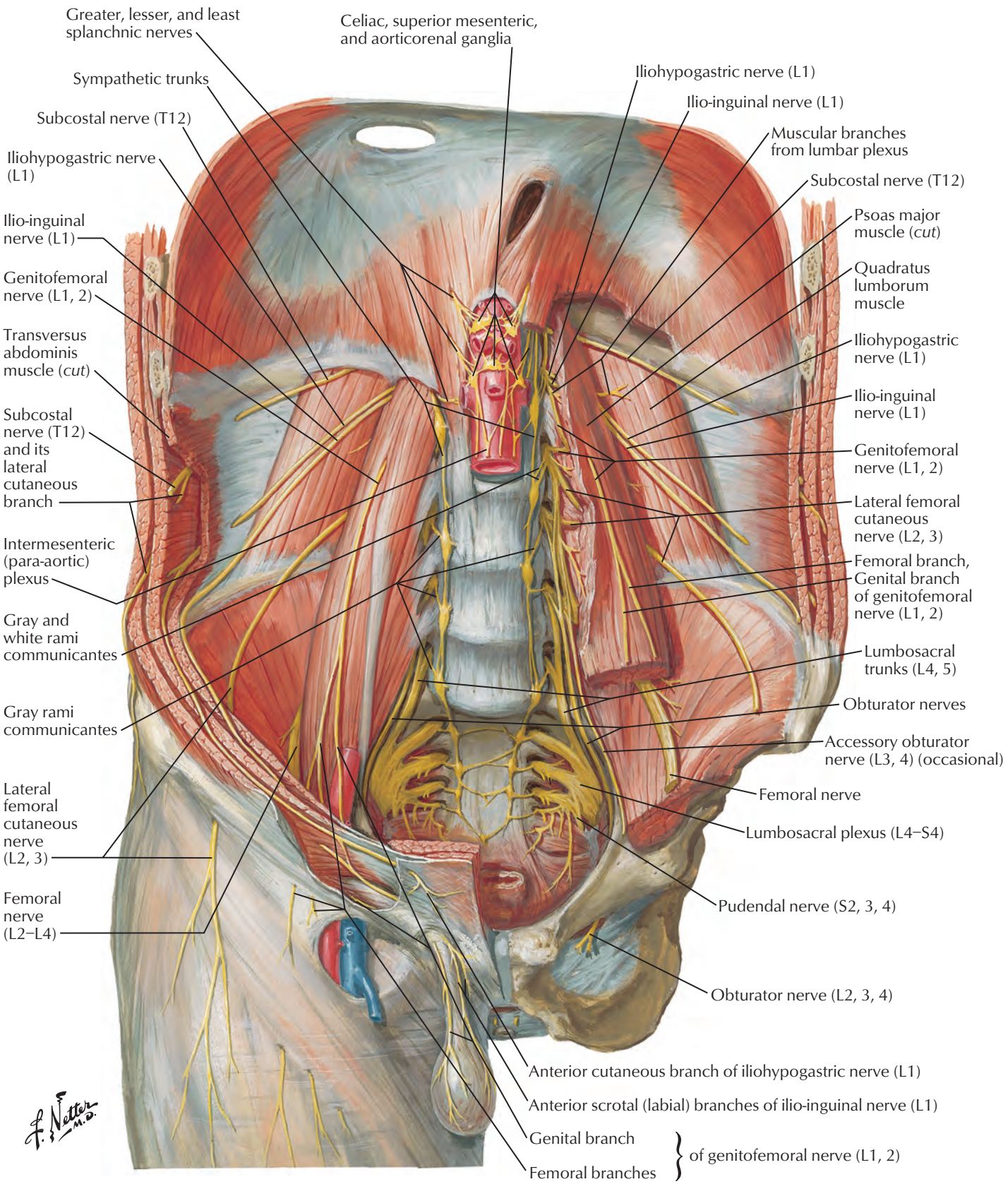


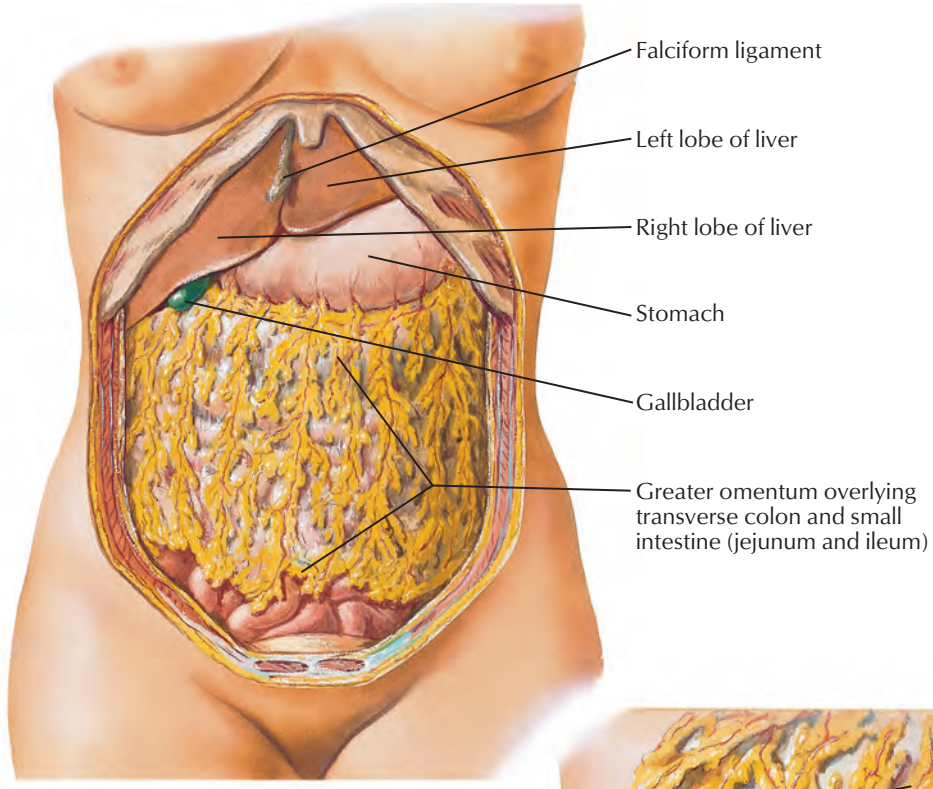

Inferior phrenic veins
Diaphragm
Hepatic veins
Inferior vena cava
Esophagus
Right inferior suprarenal vein
Left suprarenal veins and anastomosis with inferior phrenic vein
Right renal vein
Left renal vein
Psoas major muscle (*cut*)
Ovarian (testicular) veins
Quadratus lumborum muscle
Ascending lumbar veins
Subcostal vein
Common iliac vein
1st to 4th right lumbar veins
Internal iliac vein
Iliolumbar vein
Superior gluteal vein
Common iliac vein
Inferior gluteal vein
Ovarian (testicular) veins and ureter (*cut*)
Internal pudendal vein
Internal iliac vein
External iliac vein
Median sacral vein
Middle rectal vein
Lateral sacral veins
Uterine vein
Superior vesical vein
Deep circumflex iliac vein
Deep circumflex iliac vein
Superficial circumflex iliac vein
Obturator vein
Round ligament of uterus
Inferior epigastric vein (*cut*)
Inferior epigastric vein
Rectal venous plexus
Superficial epigastric vein (*cut*)
Pubic (obturator anastomotic) vein
Uterovaginal venous plexus
Femoral vein
Great saphenous vein
Vesical venous plexus
External pudendal vein
Anterior abdominal wall (*turned down*)

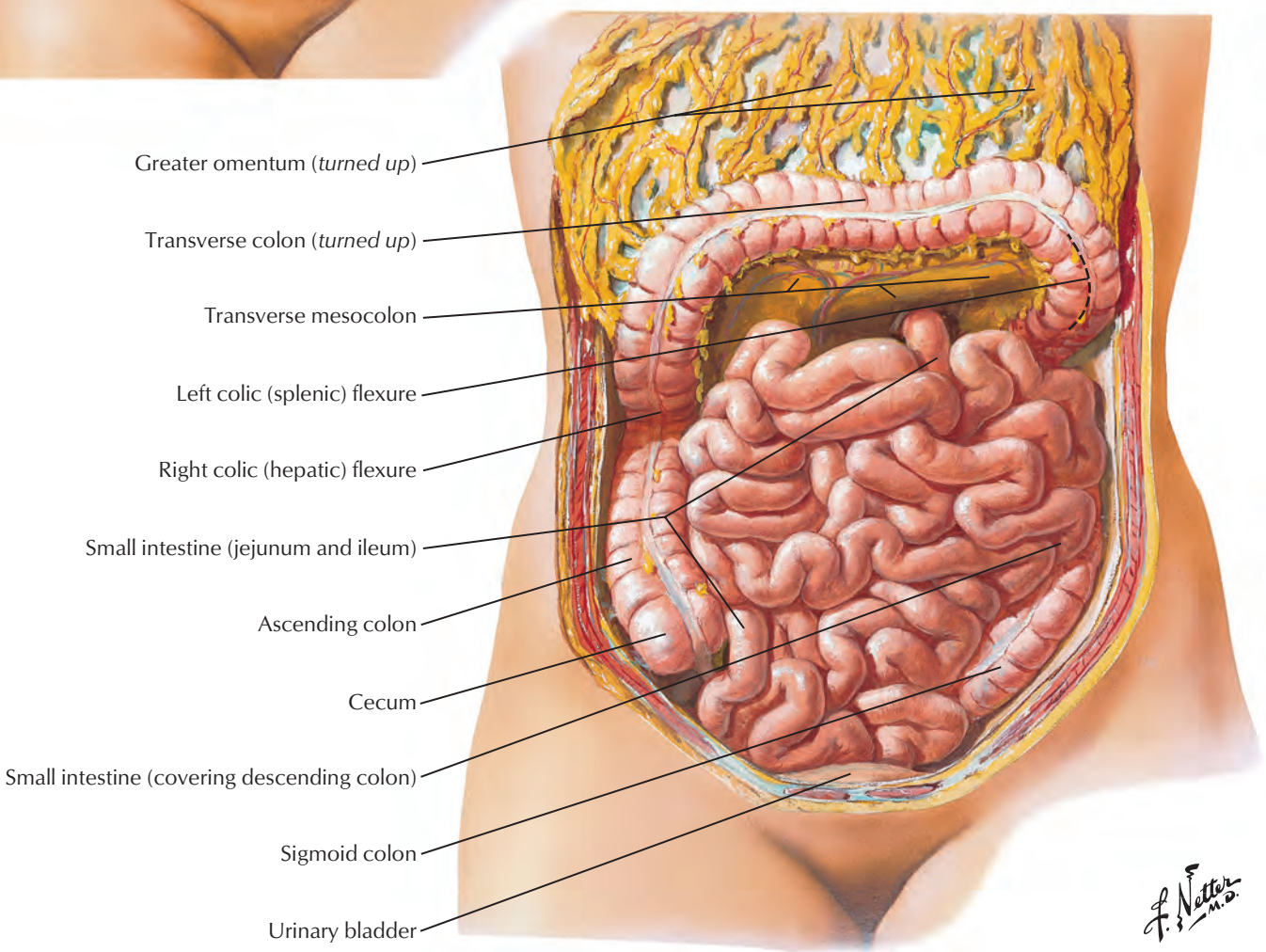
Lymph Vessels and Nodes of Posterior Abdominal Wall

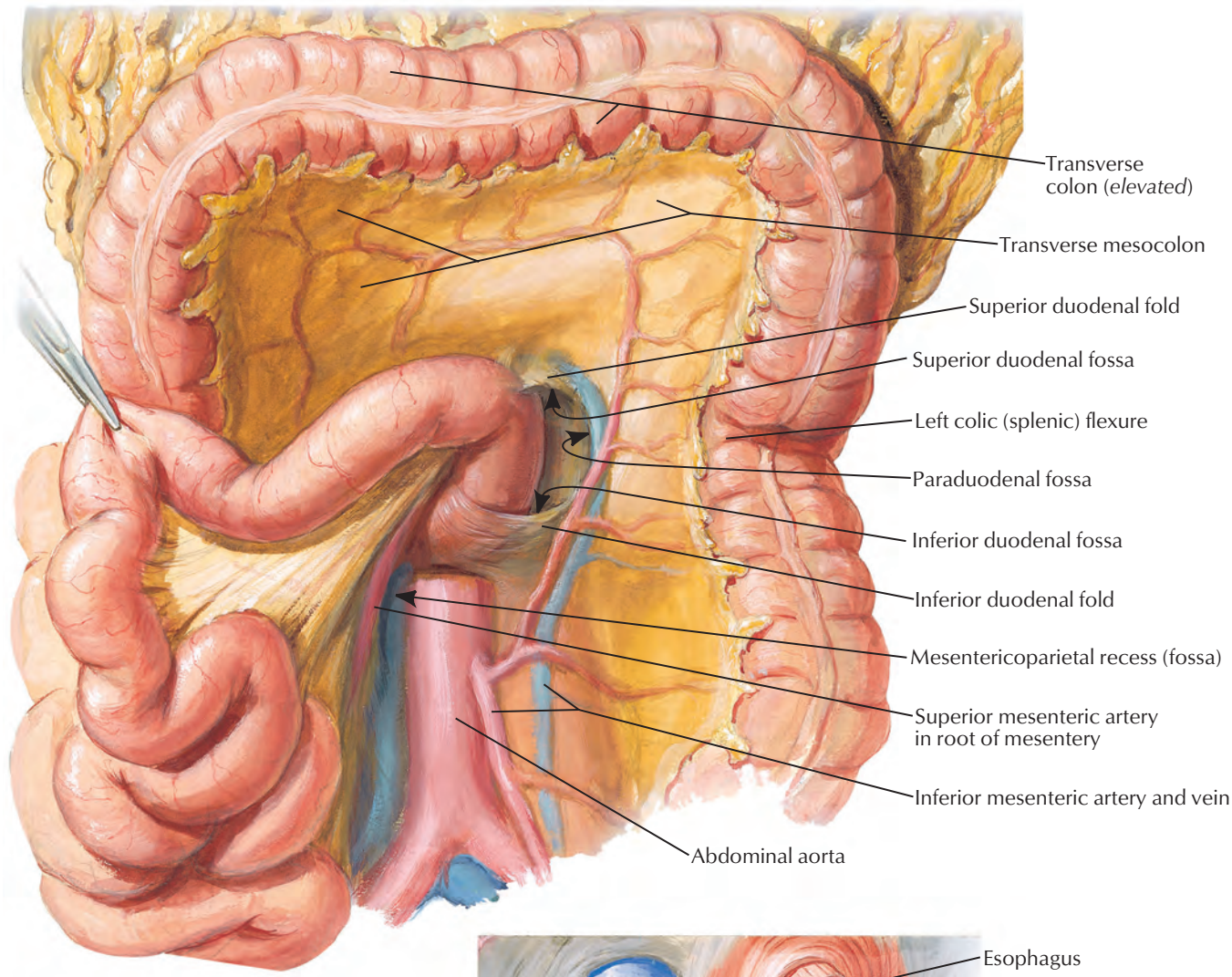
See also **Plates 235, 384**



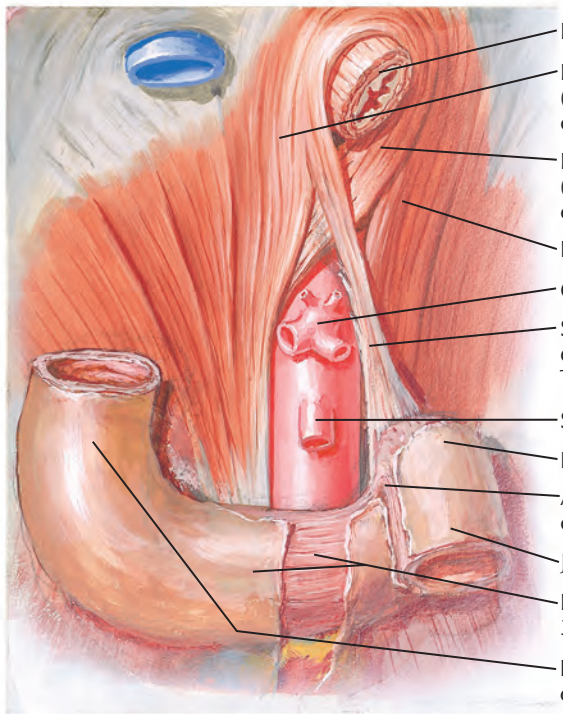

Greater, lesser, and least splanchnic nerves
Celiac, superior mesenteric, and aorticorenal ganglia
Sympathetic trunks
Iliohypogastric nerve (L1)
Ilio-inguinal nerve (L1)
Subcostal nerve (T12)
Muscular branches from lumbar plexus
Iliohypogastric nerve (L1)
Subcostal nerve (T12)
Ilio-inguinal nerve (L1)
Psoas major muscle (*cut*)
Genitofemoral nerve (L1, 2)
Quadratus lumborum muscle
Transversus abdominis muscle (*cut*)
Iliohypogastric nerve (L1)
Ilio-inguinal nerve (L1)
Subcostal nerve (T12) and its lateral cutaneous branch
Genitofemoral nerve (L1, 2)
Lateral femoral cutaneous nerve (L2, 3)
Intermesenteric (para-aortic) plexus
Femoral branch, Genital branch of genitofemoral nerve (L1, 2)
Gray and white rami communicantes
Lumbosacral trunks (L4, 5)
Obturator nerves
Gray rami communicantes
Accessory obturator nerve (L3, 4) (occasional)
Femoral nerve
Lateral femoral cutaneous nerve (L2, 3)
Lumbosacral plexus (L4–S4)
Femoral nerve (L2–L4)
Pudendal nerve (S2, 3, 4)
Obturator nerve (L2, 3, 4)
Anterior cutaneous branch of iliohypogastric nerve (L1)
Anterior scrotal (labial) branches of ilio-inguinal nerve (L1)
Genital branch
Femoral branches
of genitofemoral nerve (L1, 2)


Falciform ligament
Left lobe of liver
Right lobe of liver
Stomach
Gallbladder
Greater omentum overlying transverse colon and small intestine (jejunum and ileum)


Greater omentum (*turned up*)
Transverse colon (*turned up*)
Transverse mesocolon
Left colic (splenic) flexure
Right colic (hepatic) flexure
Small intestine (jejunum and ileum)
Ascending colon
Cecum
Small intestine (covering descending colon)
Sigmoid colon
Urinary bladder

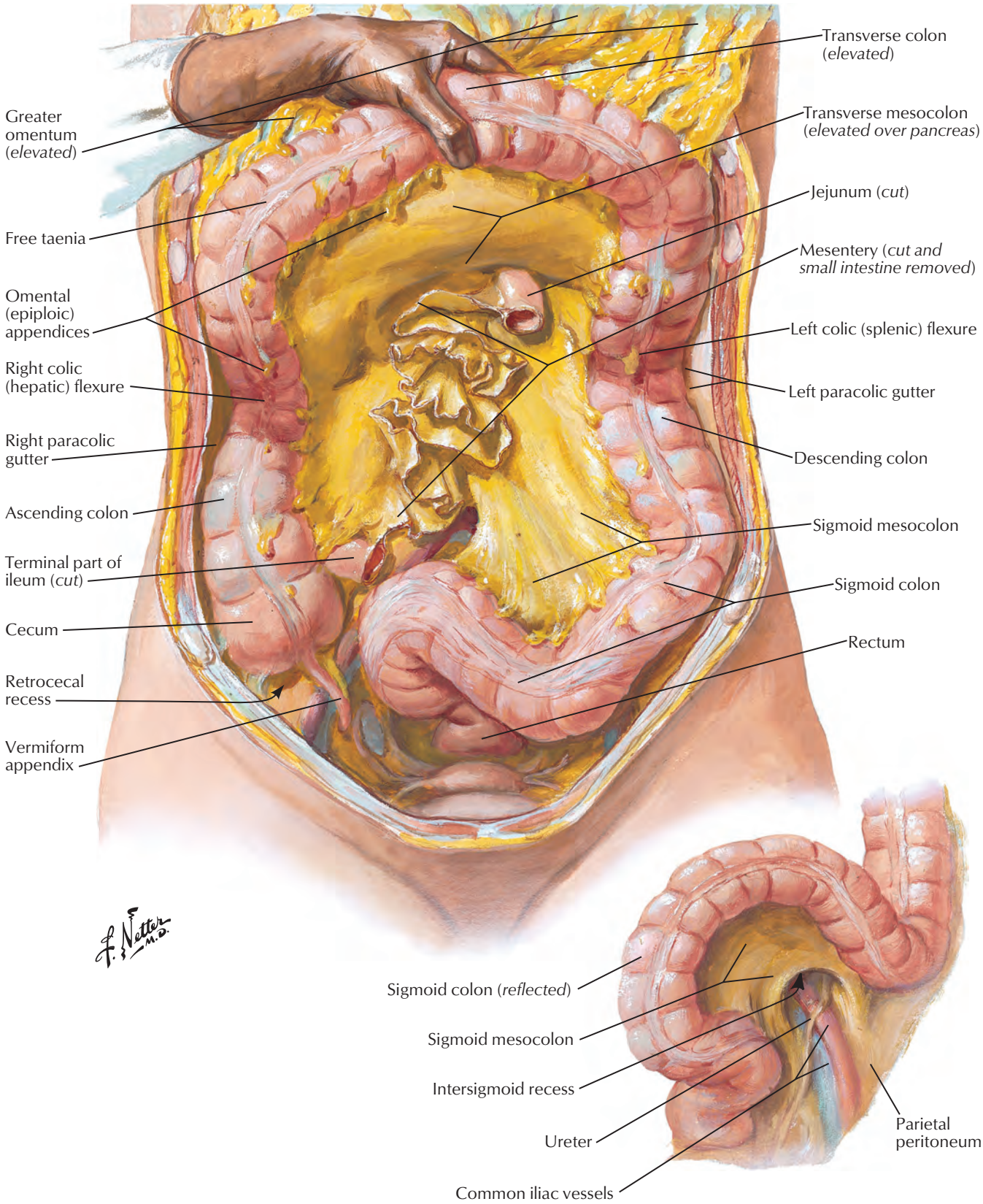


Exposure of suspensory muscle of duodenum (ligament of Treitz)



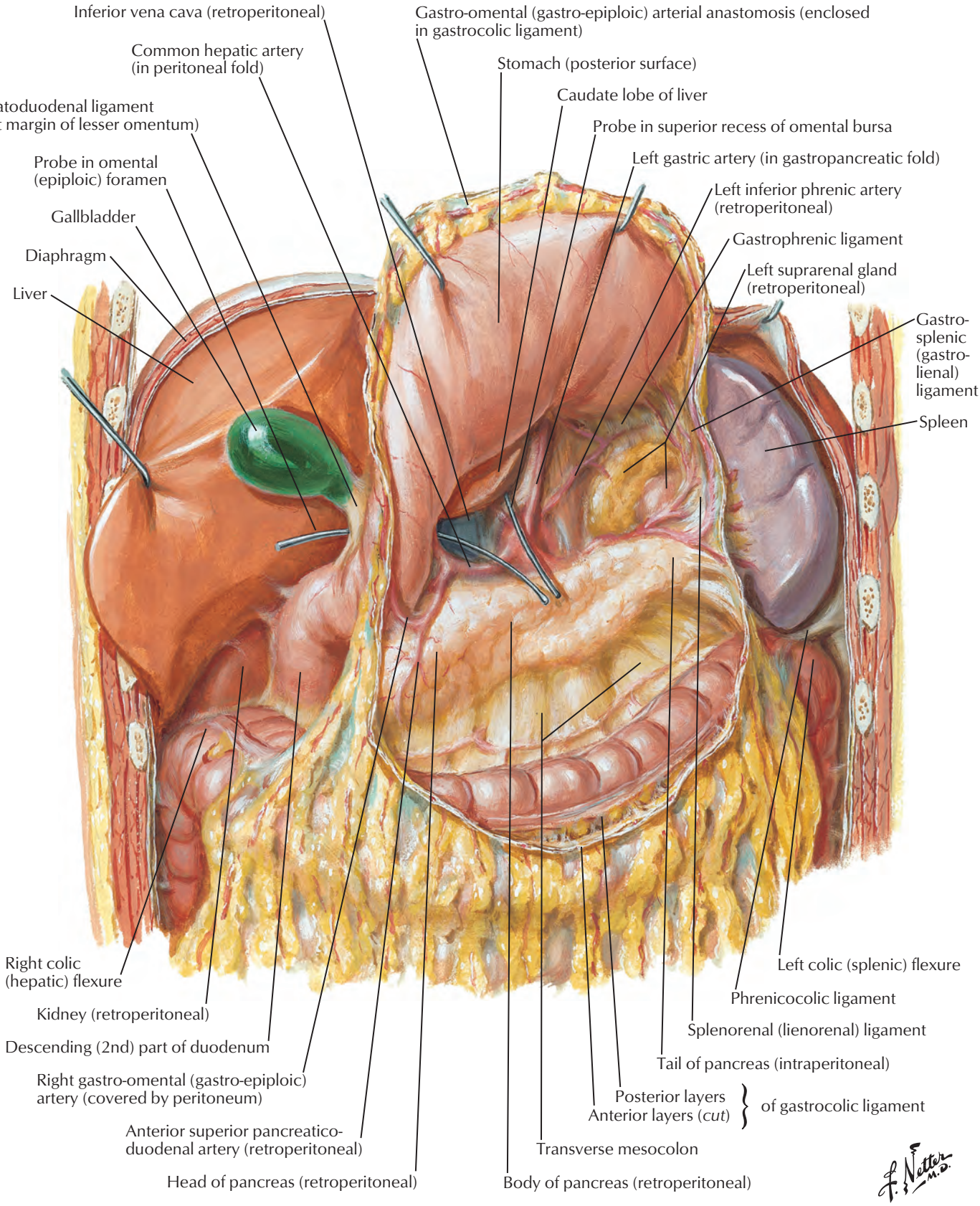
Mesenteric Relations of Intestines (continued)

See also Plate 268



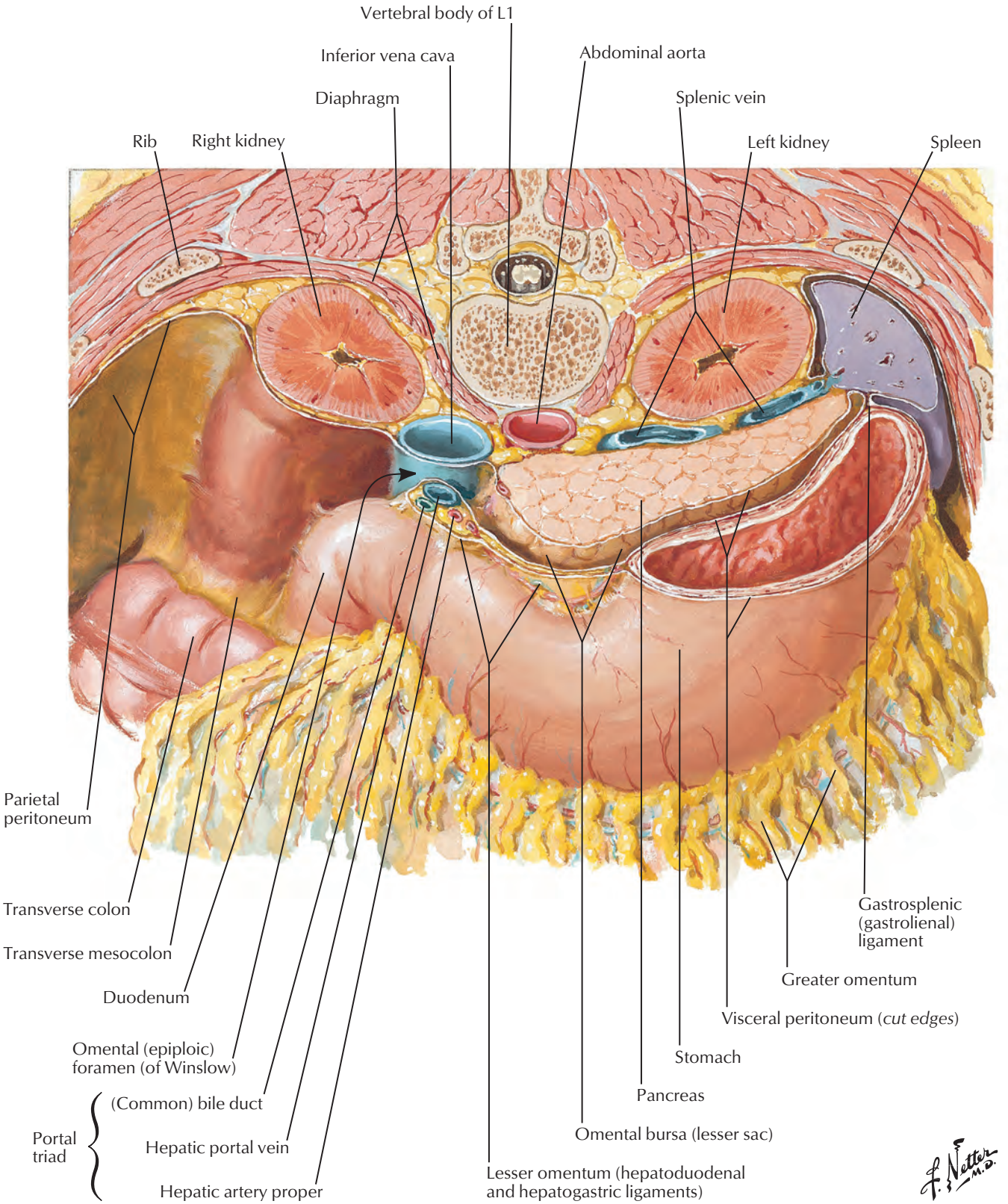
Omental Bursa: Stomach Reflected

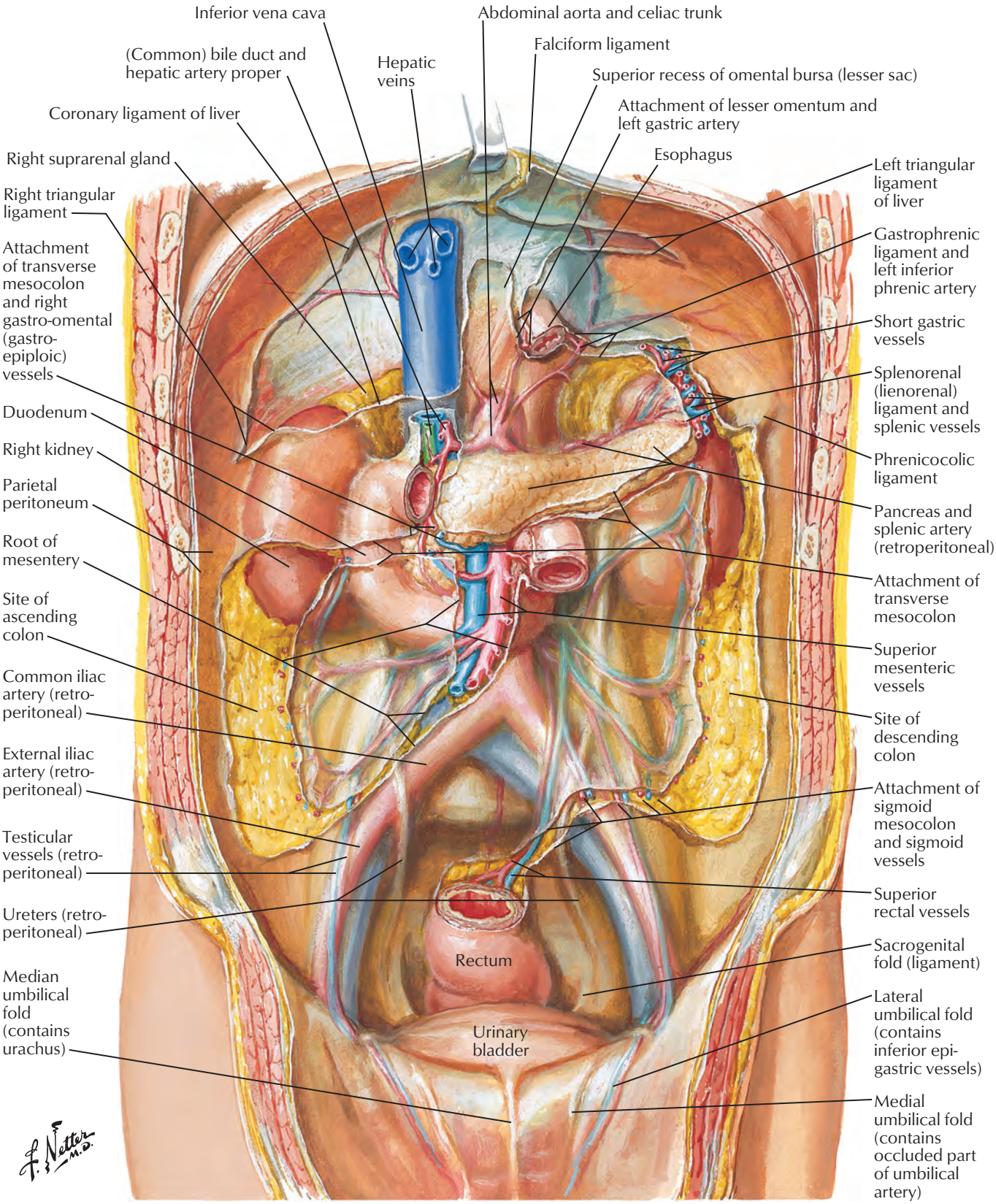
See also Plates 263, 264

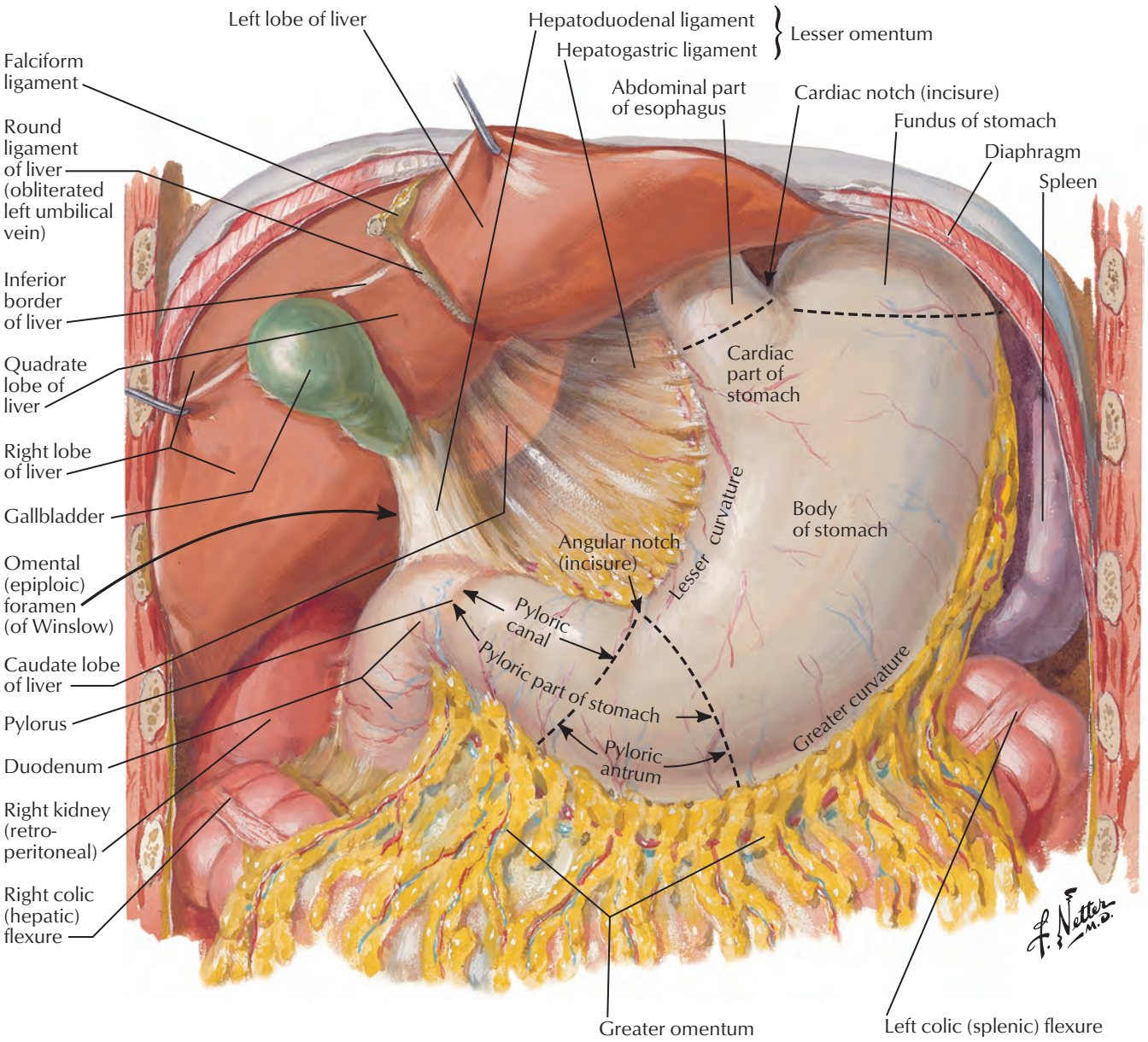


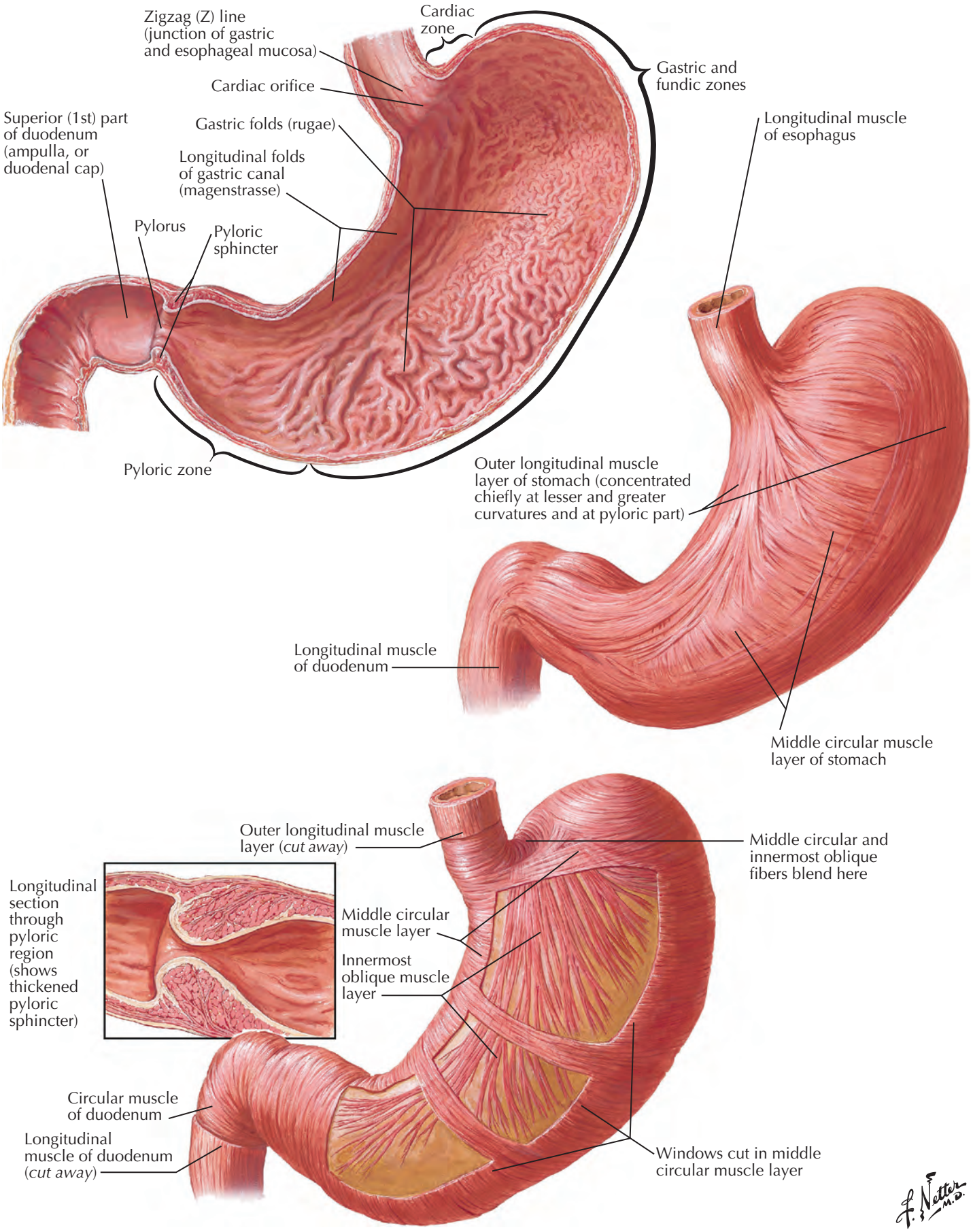
Omental Bursa: Cross Section

See also Plate 269



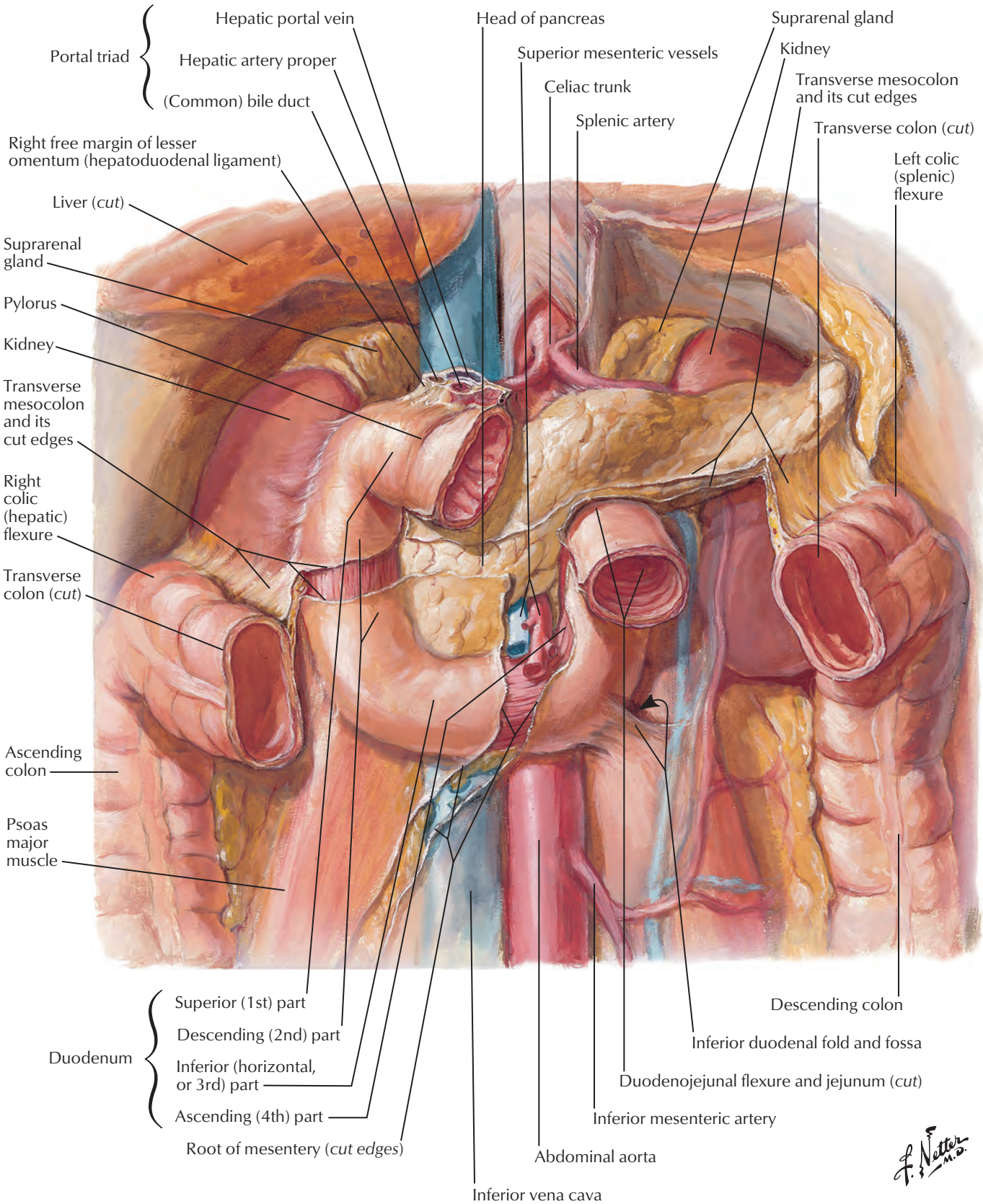

Inferior vena cava
Abdominal aorta and celiac trunk
(Common) bile duct and hepatic artery proper
Hepatic veins
Falciform ligament
Superior recess of omental bursa (lesser sac)
Coronary ligament of liver
Attachment of lesser omentum and left gastric artery
Right suprarenal gland
Esophagus
Left triangular ligament of liver
Right triangular ligament
Gastrophrenic ligament and left inferior phrenic artery
Attachment of transverse mesocolon and right gastro-omental (gastro-epiploic) vessels
Short gastric vessels
Splenorenal (lienorenal) ligament and splenic vessels
Duodenum
Phrenicocolic ligament
Right kidney
Pancreas and splenic artery (retroperitoneal)
Parietal peritoneum
Root of mesentery
Attachment of transverse mesocolon
Site of ascending colon
Superior mesenteric vessels
Common iliac artery (retro-peritoneal)
Site of descending colon
External iliac artery (retro-peritoneal)
Attachment of sigmoid mesocolon and sigmoid vessels
Testicular vessels (retro-peritoneal)
Superior rectal vessels
Ureters (retro-peritoneal)
Rectum
Sacrogenital fold (ligament)
Median umbilical fold (contains urachus)
Lateral umbilical fold (contains inferior epi-gastric vessels)
Urinary bladder
Medial umbilical fold (contains occluded part of umbilical artery)
F. Netter M.D.

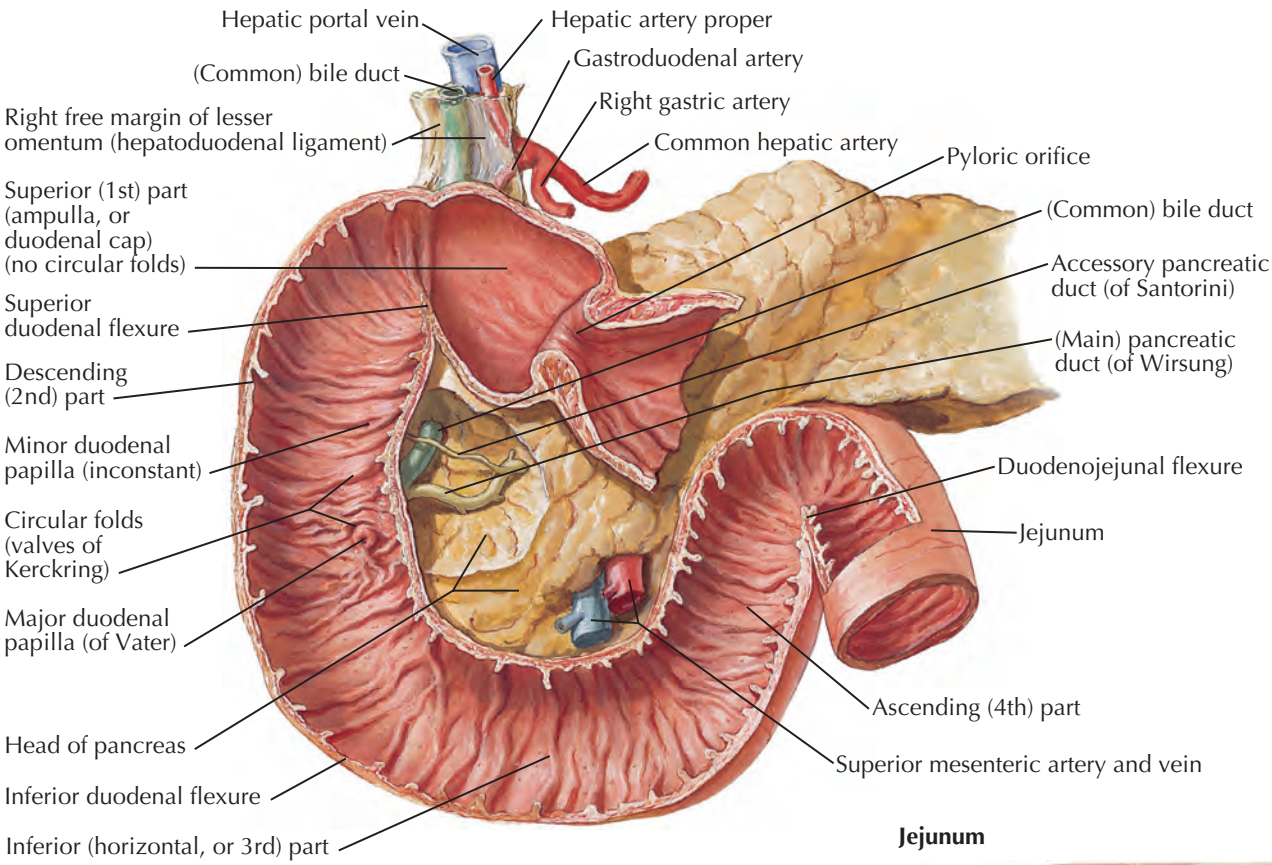

Left lobe of liver
Hepatoduodenal ligament
Hepatogastric ligament
Lesser omentum
Falciform ligament
Round ligament of liver (obliterated left umbilical vein)
Abdominal part of esophagus
Cardiac notch (incisure)
Fundus of stomach
Diaphragm
Spleen
Inferior border of liver
Quadrate lobe of liver
Right lobe of liver
Gallbladder
Omental (epiploic) foramen (of Winslow)
Caudate lobe of liver
Pylorus
Duodenum
Right kidney (retro-peritoneal)
Right colic (hepatic) flexure
Cardiac part of stomach
Body of stomach
Angular notch (incisure)
Lesser curvature
Pyloric canal
Pyloric part of stomach
Pyloric antrum
Greater curvature
Greater omentum
Left colic (splenic) flexure


Zigzag (Z) line (junction of gastric and esophageal mucosa)
Cardiac zone
Cardiac orifice
Gastric and fundic zones
Superior (1st) part of duodenum (ampulla, or duodenal cap)
Gastric folds (rugae)
Longitudinal folds of gastric canal (magenstrasse)
Pylorus
Pyloric sphincter
Pyloric zone
Longitudinal muscle of esophagus
Outer longitudinal muscle layer of stomach (concentrated chiefly at lesser and greater curvatures and at pyloric part)
Longitudinal muscle of duodenum
Middle circular muscle layer of stomach
Outer longitudinal muscle layer (cut away)
Middle circular and innermost oblique fibers blend here
Longitudinal section through pyloric region (shows thickened pyloric sphincter)
Middle circular muscle layer
Innermost oblique muscle layer
Circular muscle of duodenum
Longitudinal muscle of duodenum (cut away)
Windows cut in middle circular muscle layer

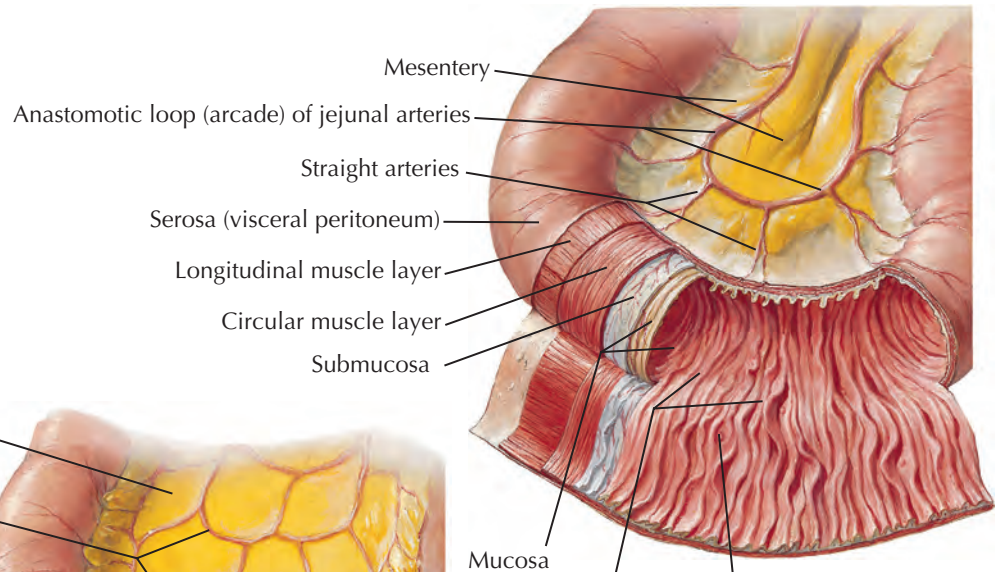
Duodenum in Situ

See also Plate 268

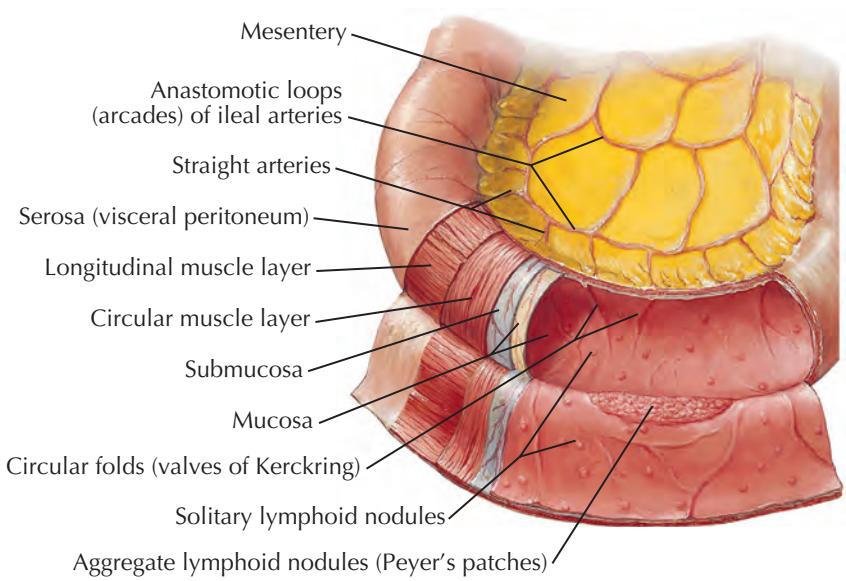


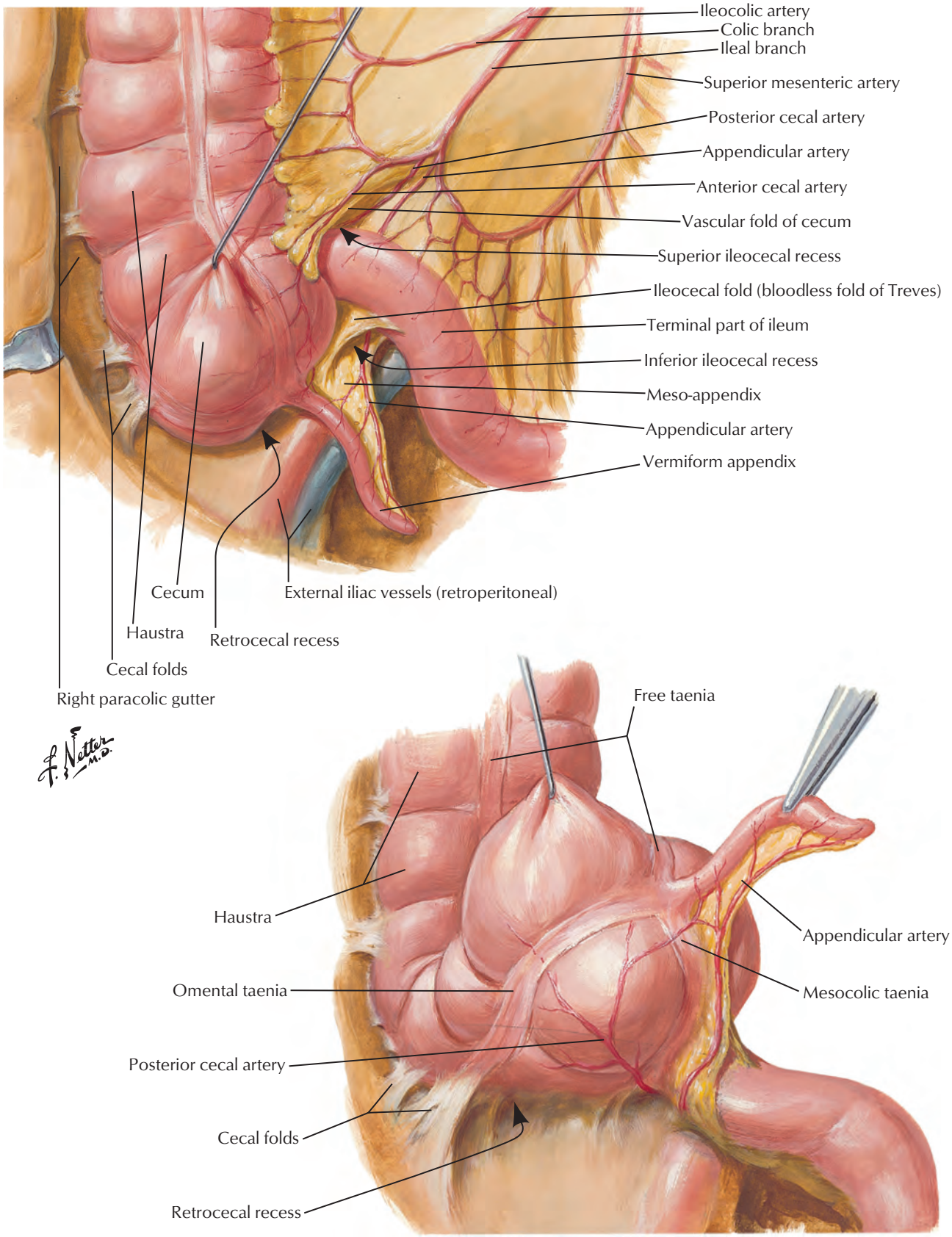


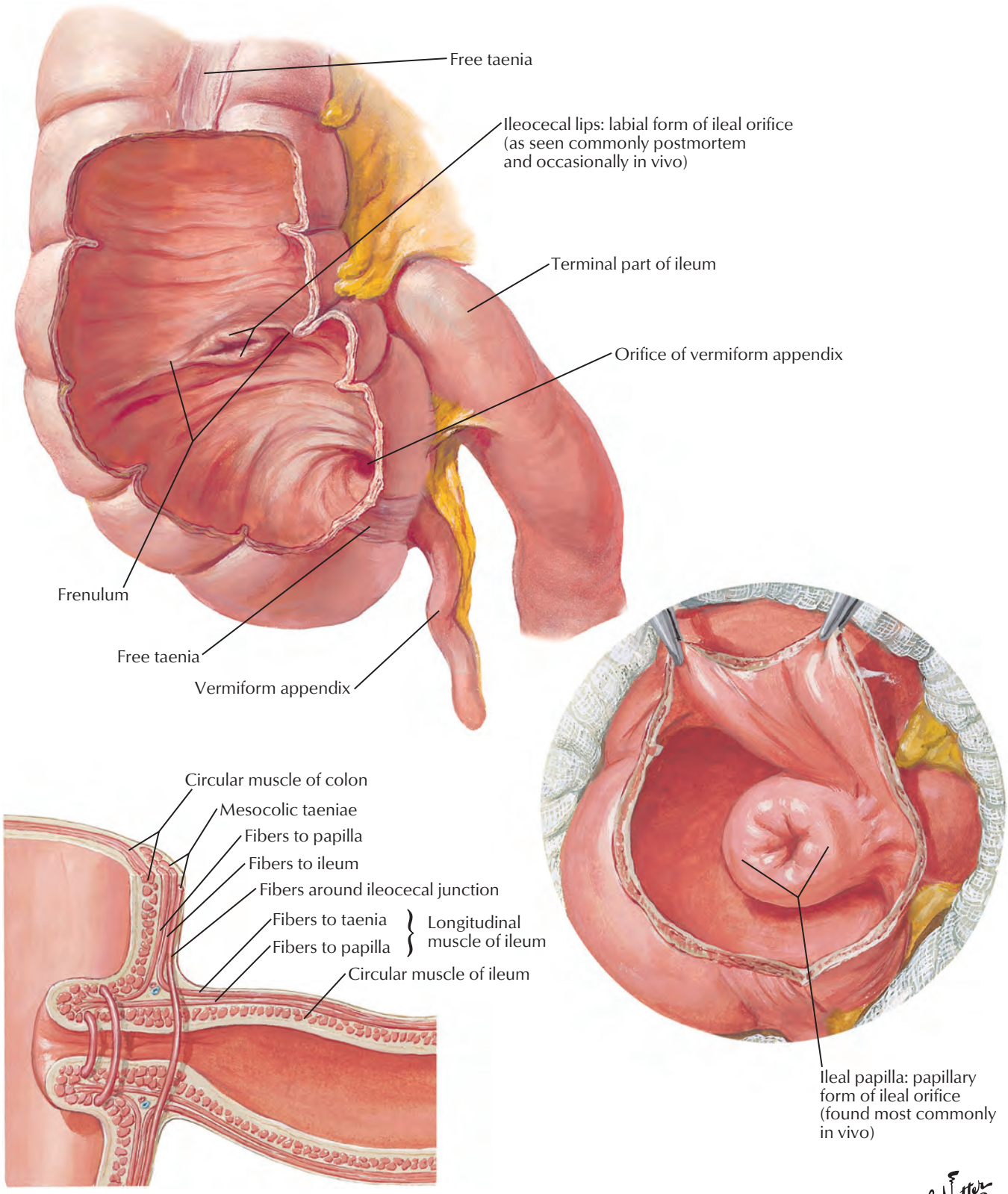
Jejunum



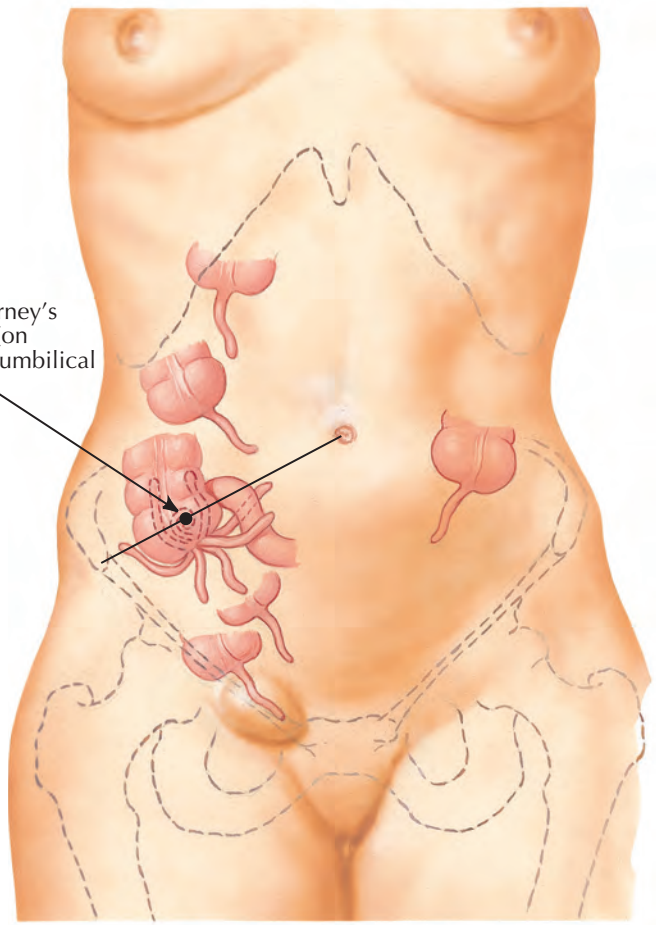
Ileum




Ileocolic artery
Colic branch
Ileal branch
Superior mesenteric artery
Posterior cecal artery
Appendicular artery
Anterior cecal artery
Vascular fold of cecum
Superior ileocecal recess
Ileocecal fold (bloodless fold of Treves)
Terminal part of ileum
Inferior ileocecal recess
Meso-appendix
Appendicular artery
Vermiform appendix
Cecum
External iliac vessels (retroperitoneal)
Haustra
Retrocecal recess
Cecal folds
Right paracolic gutter
Free taenia
Haustra
Appendicular artery
Omental taenia
Mesocolic taenia
Posterior cecal artery
Cecal folds
Retrocecal recess

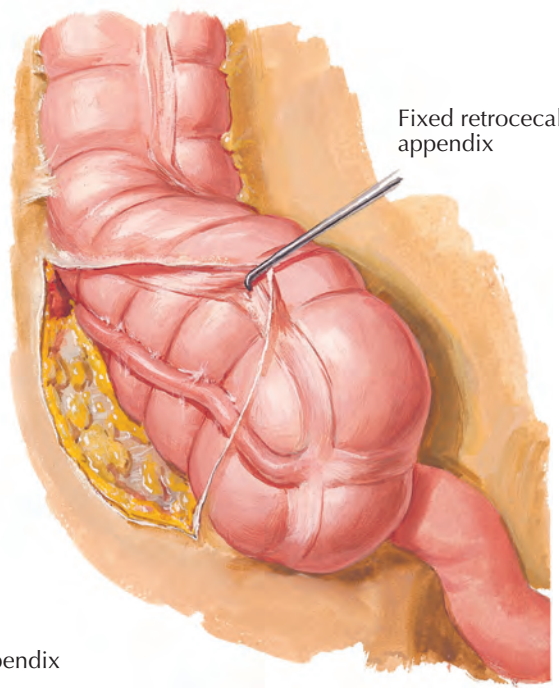


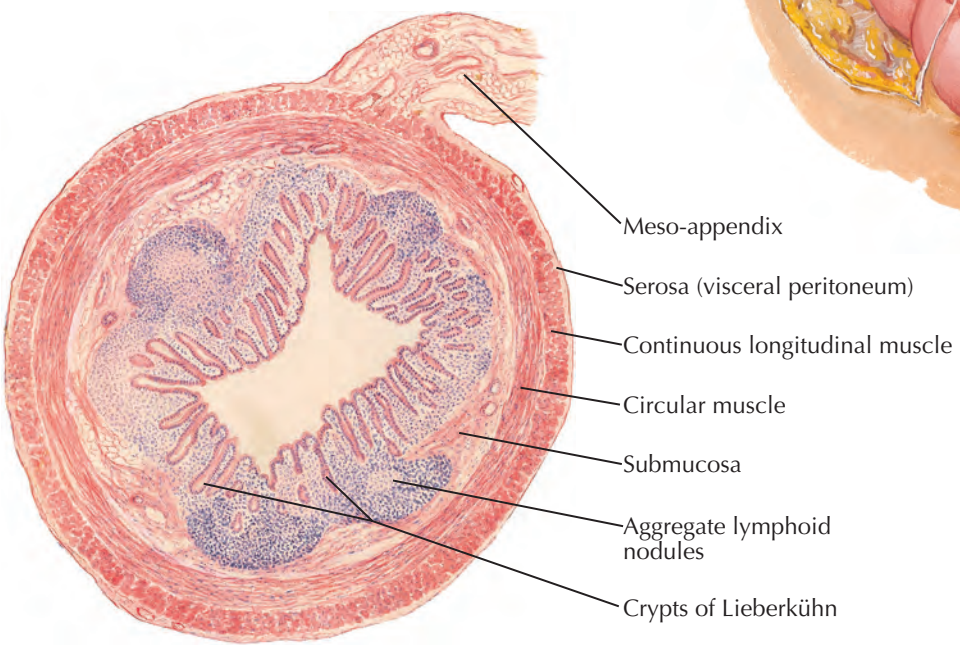
Schema of muscle fibers at ileal orifice

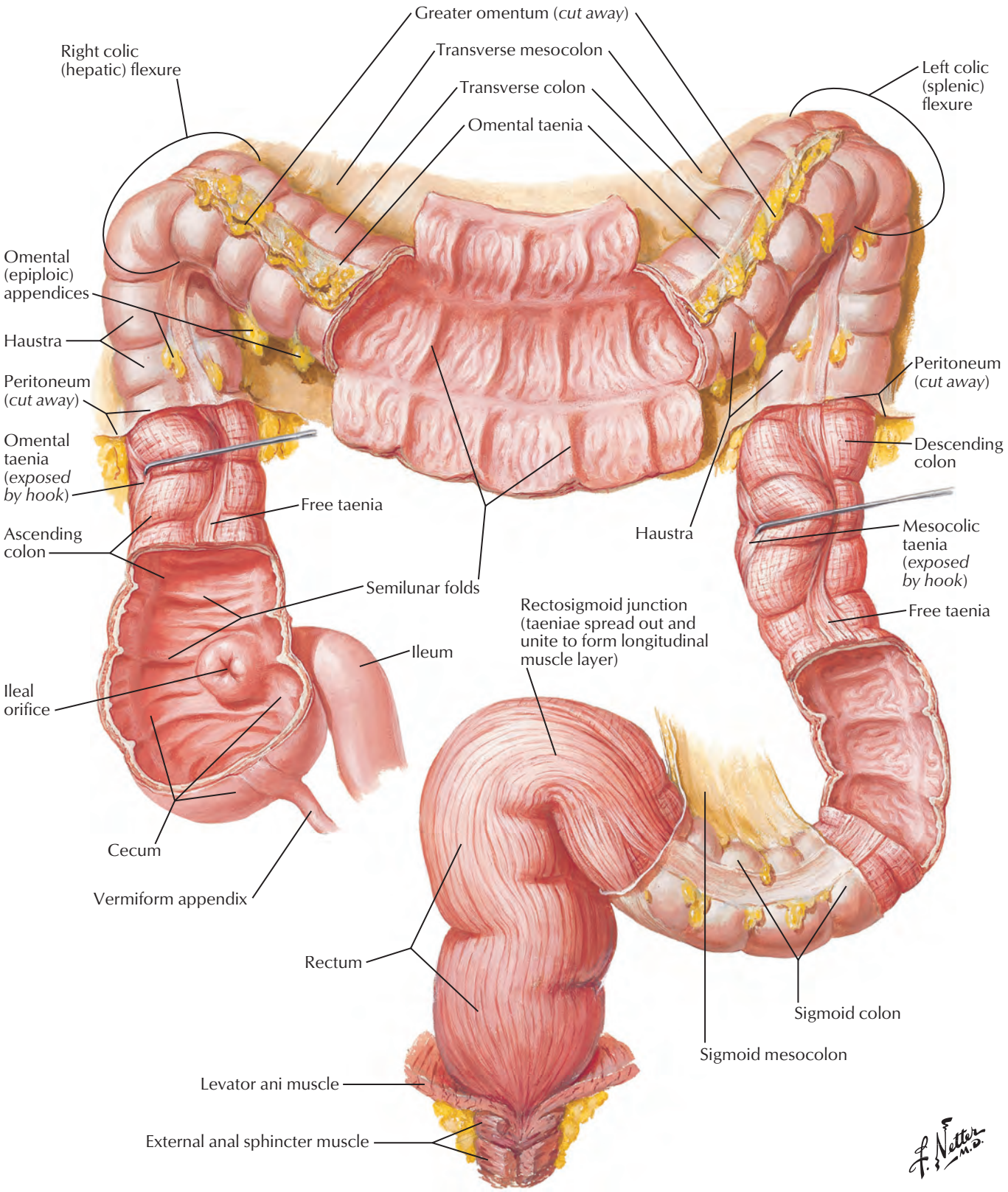


Variations in position of appendix

Coronal CT with contrast

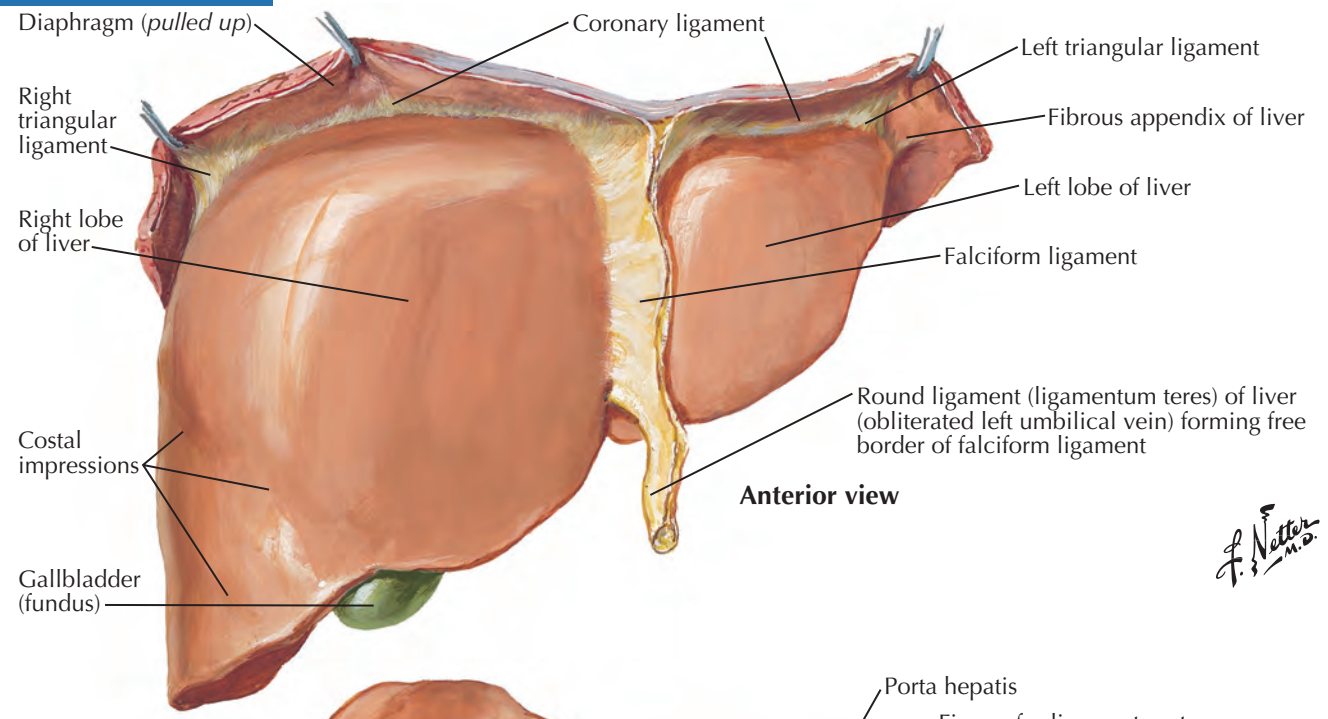




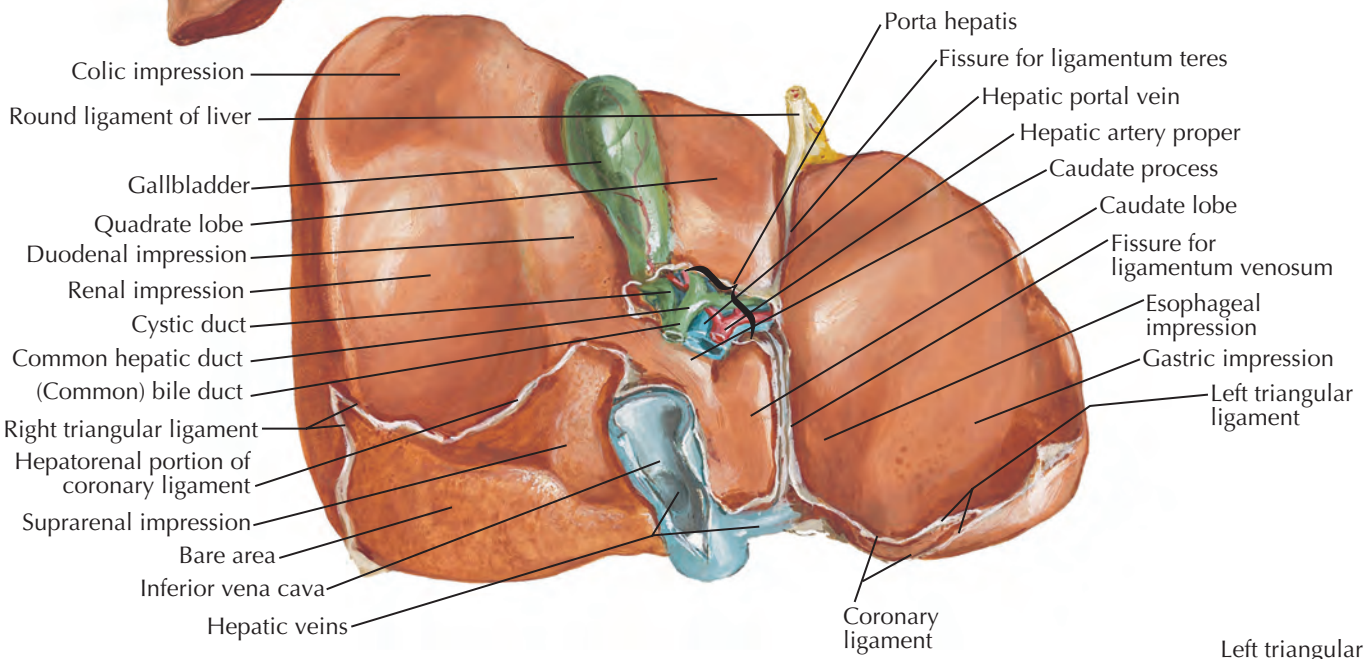

Greater omentum (*cut away*)
Right colic (hepatic) flexure
Transverse mesocolon
Transverse colon
Omental taenia
Left colic (splenic) flexure
Omental (epiploic) appendices
Haustra
Peritoneum (*cut away*)
Omental taenia (*exposed by hook*)
Ascending colon
Free taenia
Semilunar folds
Ileum
Ileal orifice
Cecum
Vermiform appendix
Rectosigmoid junction (taeniae spread out and unite to form longitudinal muscle layer)
Rectum
Levator ani muscle
External anal sphincter muscle
Haustra
Peritoneum (*cut away*)
Descending colon
Mesocolic taenia (*exposed by hook*)
Free taenia
Sigmoid colon
Sigmoid mesocolon

Surfaces and Bed of Liver

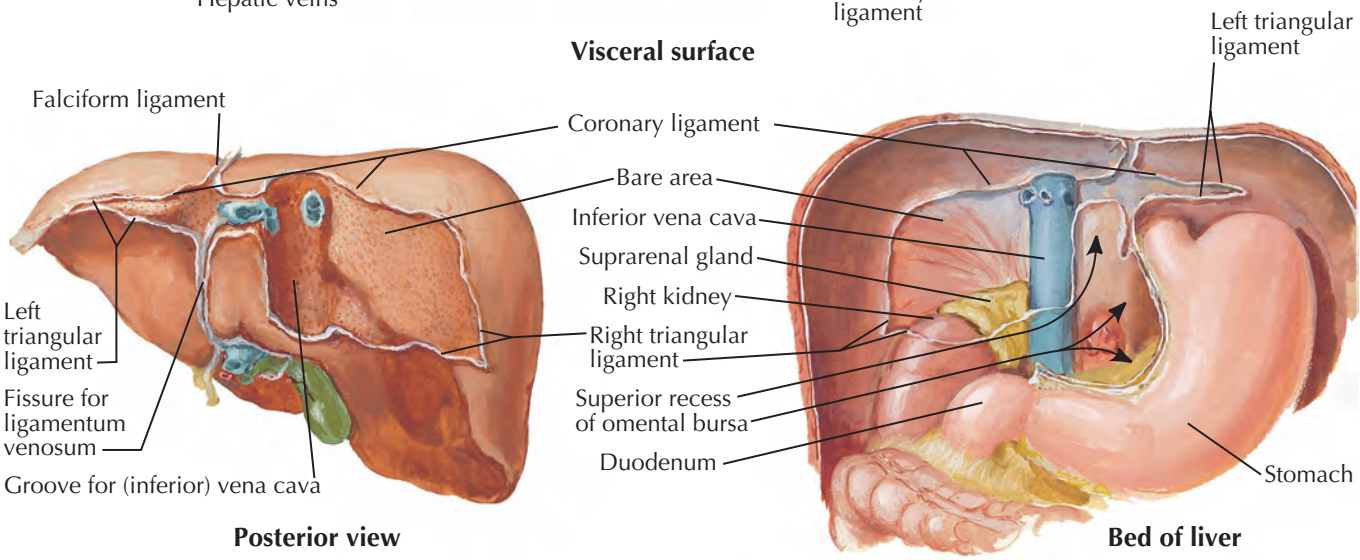
See also Plate 268



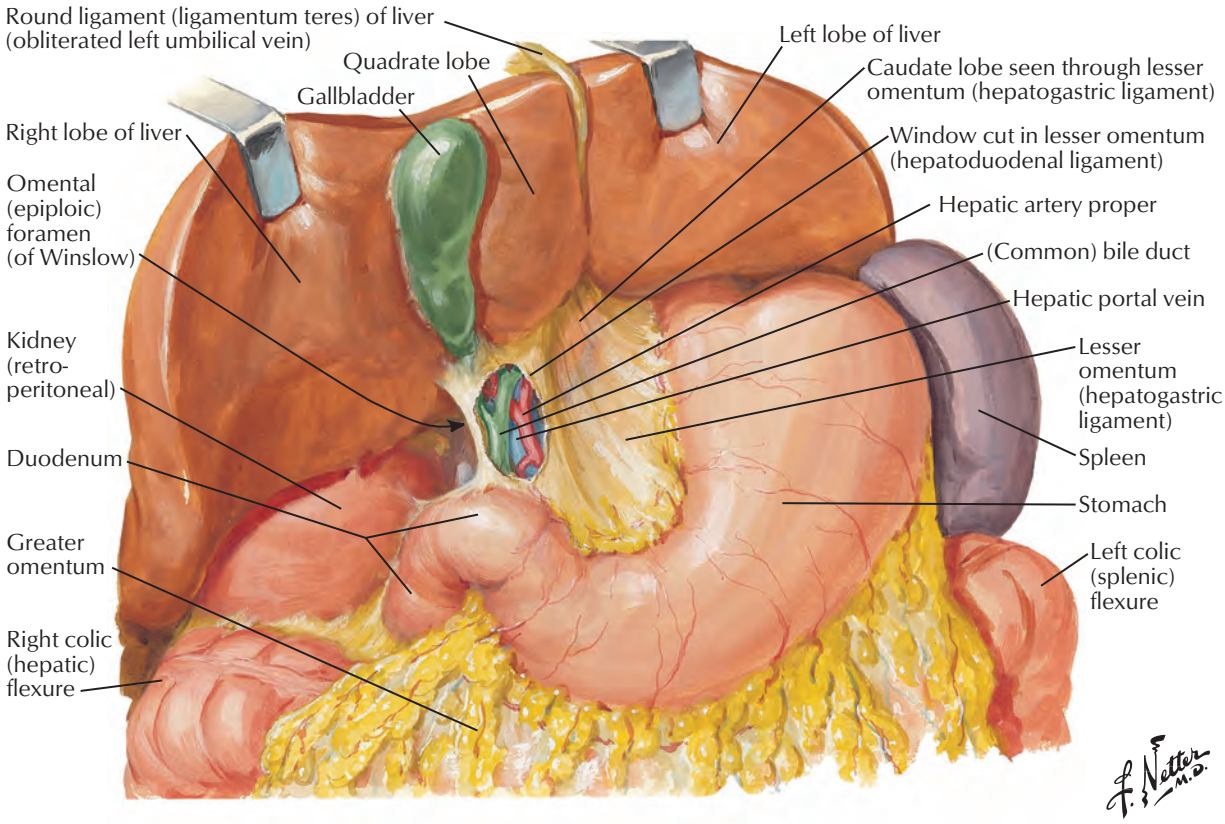
Anterior view



Visceral surface



Posterior view **Bed of liver**


Round ligament (ligamentum teres) of liver (obliterated left umbilical vein)
Quadrate lobe
Gallbladder
Right lobe of liver
Omental (epiploic) foramen (of Winslow)
Kidney (retro-peritoneal)
Duodenum
Greater omentum
Right colic (hepatic) flexure
Left lobe of liver
Caudate lobe seen through lesser omentum (hepatogastric ligament)
Window cut in lesser omentum (hepatoduodenal ligament)
Hepatic artery proper
(Common) bile duct
Hepatic portal vein
Lesser omentum (hepatogastric ligament)
Spleen
Stomach
Left colic (splenic) flexure
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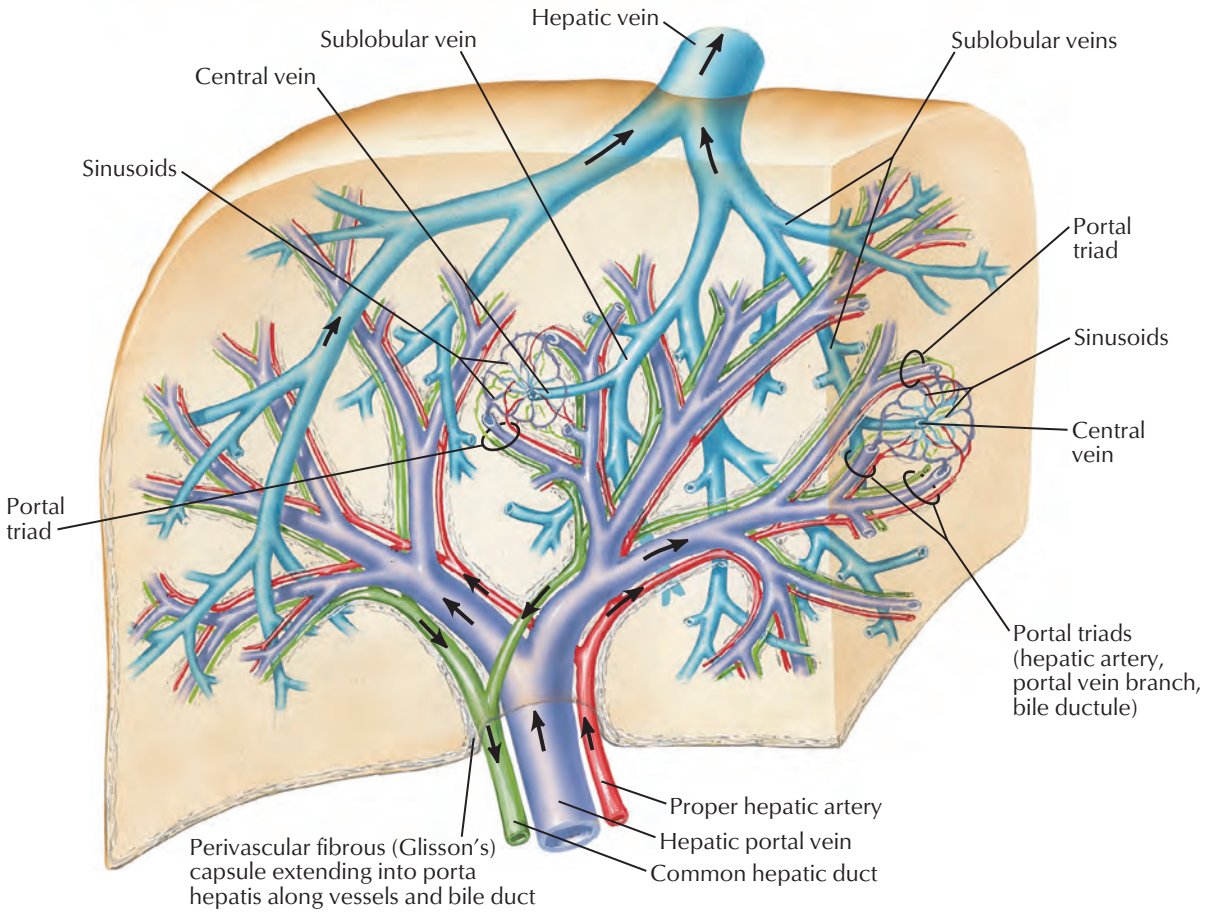
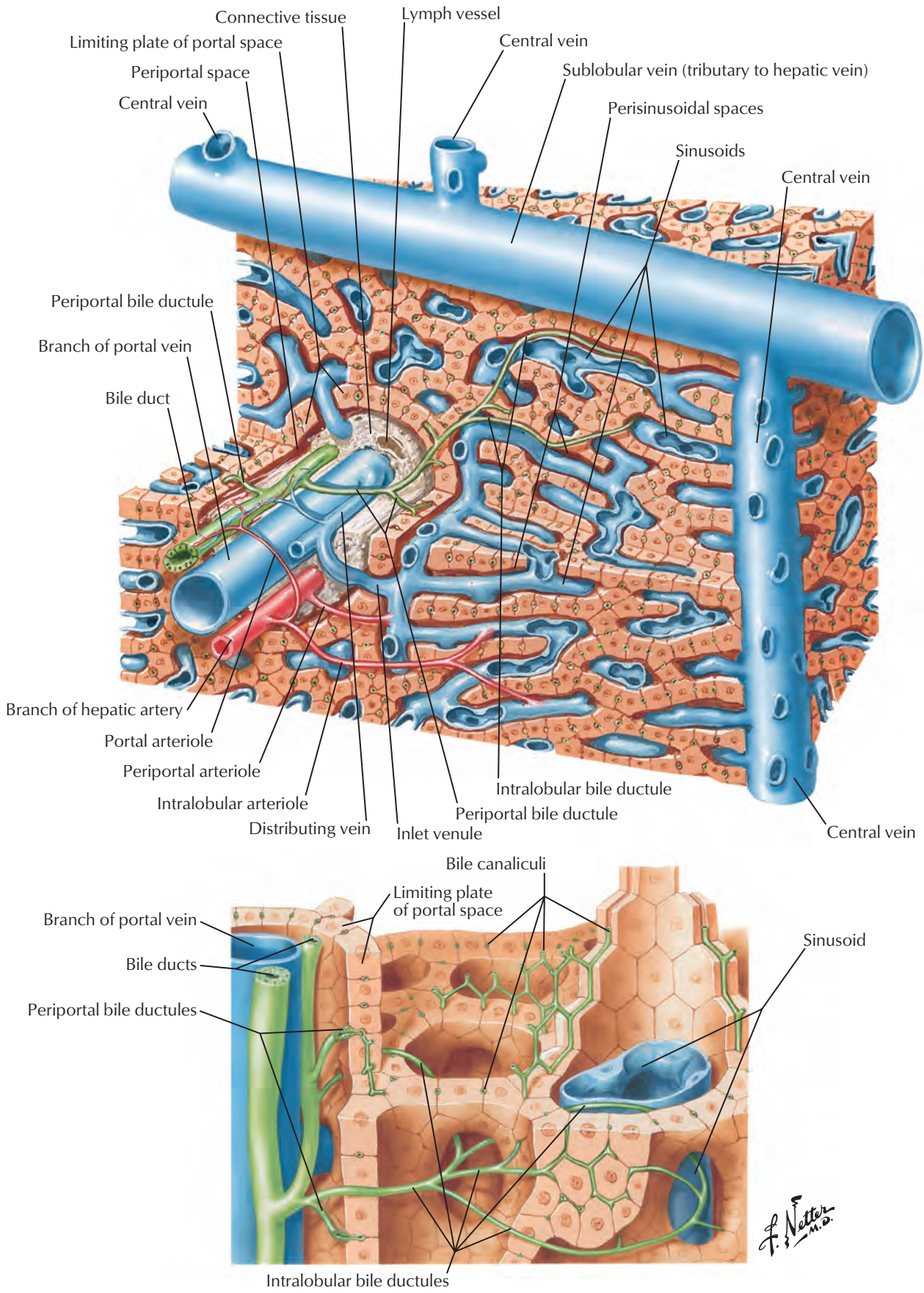
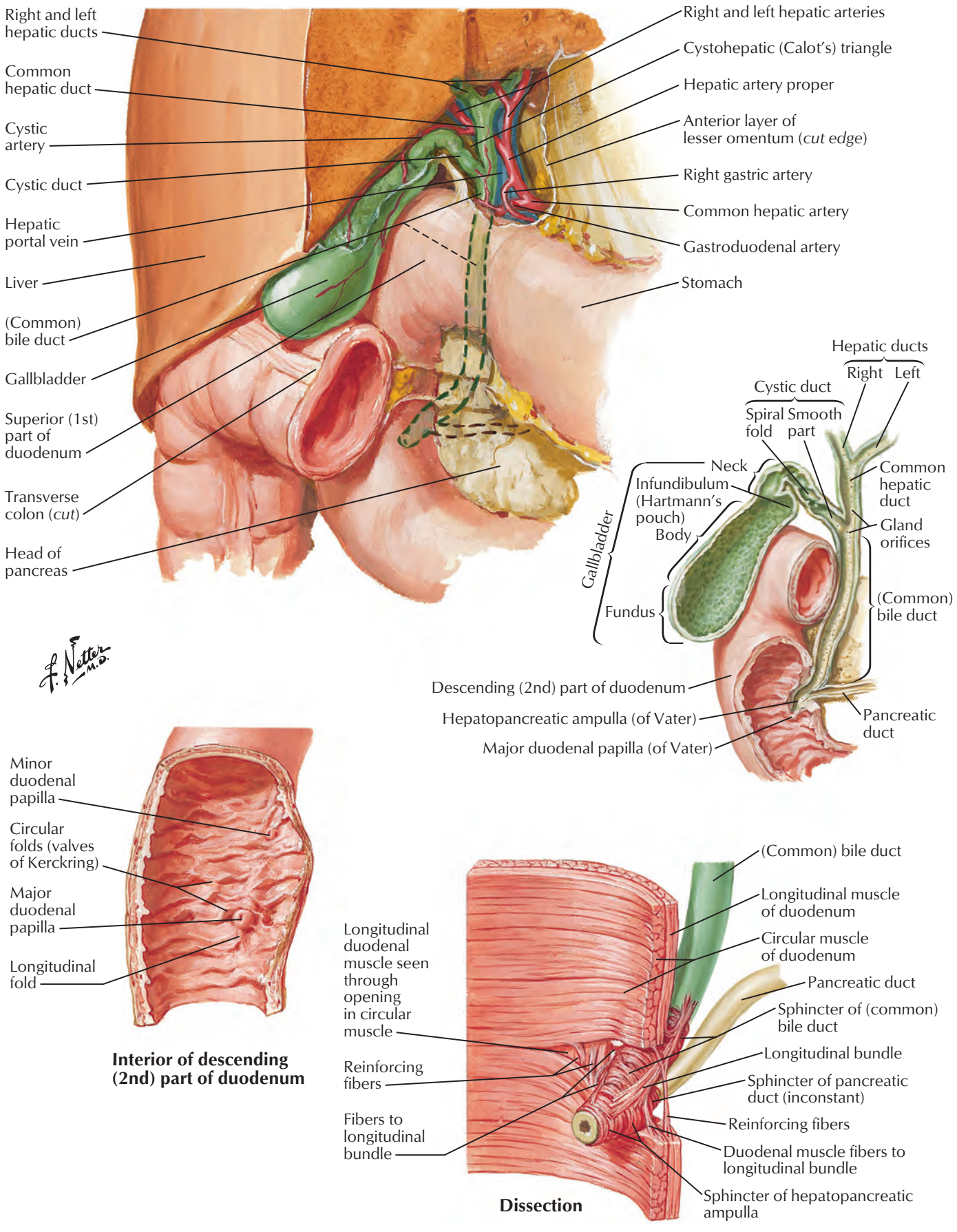
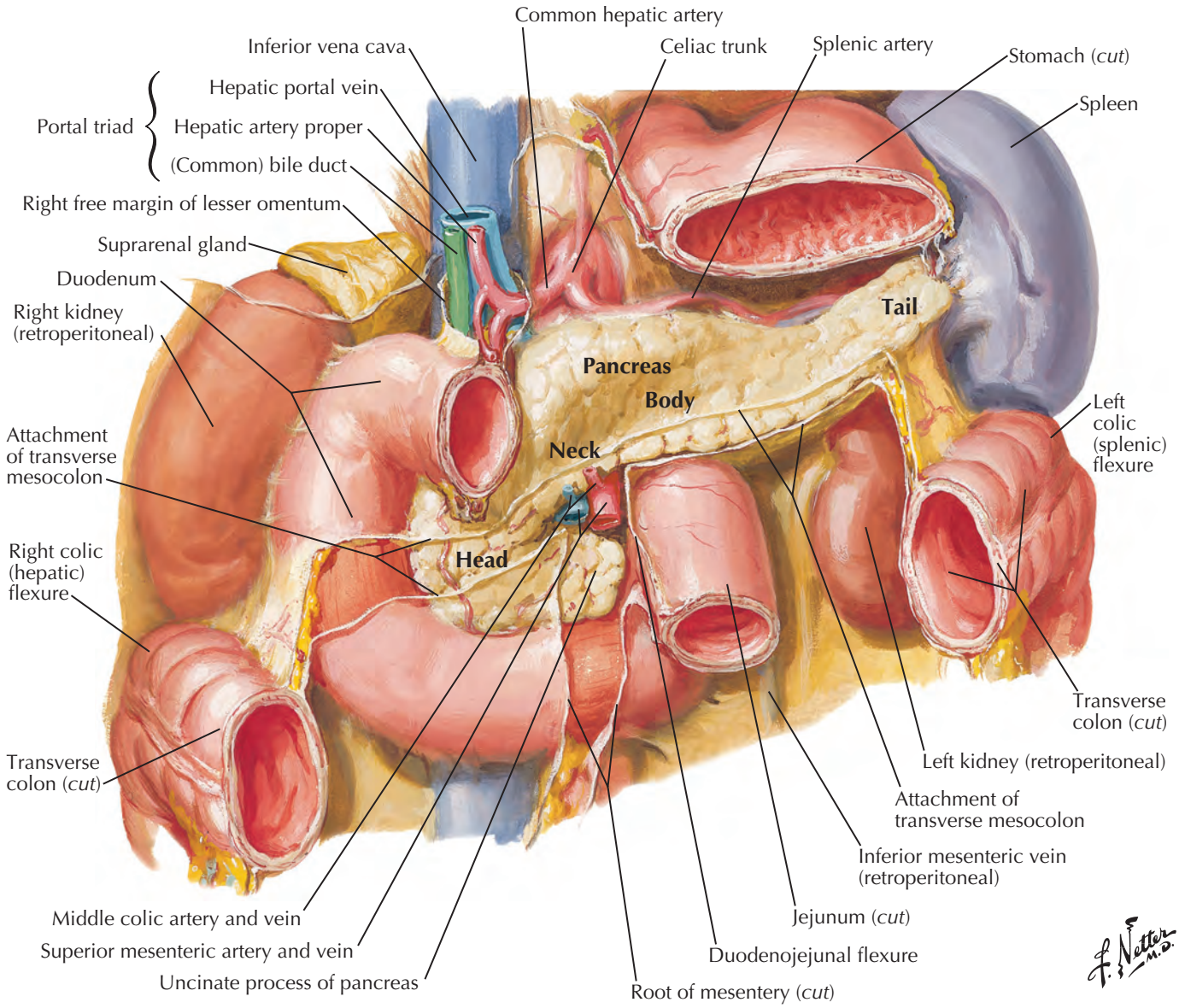
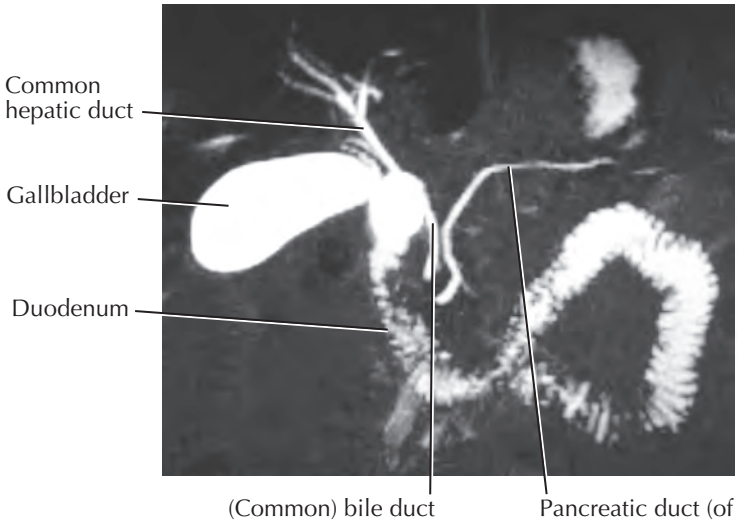

Hepatic vein
Sublobular vein
Central vein
Sinusoids
Sublobular veins
Portal triad
Sinusoids
Central vein
Portal triad
Portal triads (hepatic artery, portal vein branch, bile ductule)
Proper hepatic artery
Hepatic portal vein
Common hepatic duct
Perivascular fibrous (Glisson's) capsule extending into porta hepatis along vessels and bile duct

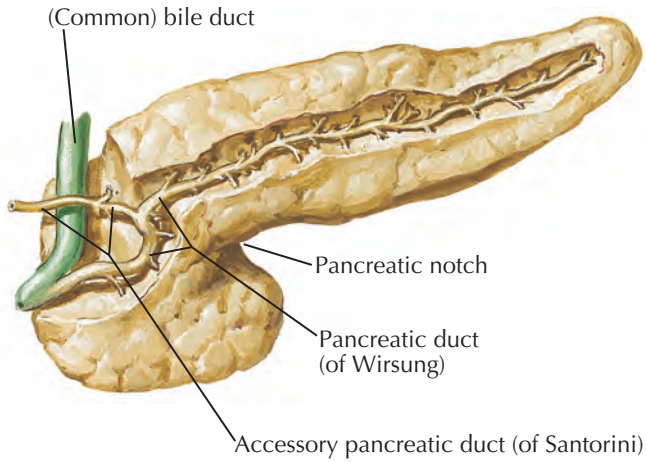

Connective tissue
Lymph vessel
Limiting plate of portal space
Central vein
Periportal space
Sublobular vein (tributary to hepatic vein)
Central vein
Perisinusoidal spaces
Sinusoids
Central vein
Periportal bile ductule
Branch of portal vein
Bile duct
Branch of hepatic artery
Portal arteriole
Periportal arteriole
Intralobular arteriole
Distributing vein
Inlet venule
Intralobular bile ductule
Periportal bile ductule
Central vein
Bile canaliculi
Limiting plate of portal space
Branch of portal vein
Bile ducts
Periportal bile ductules
Sinusoid
Intralobular bile ductules

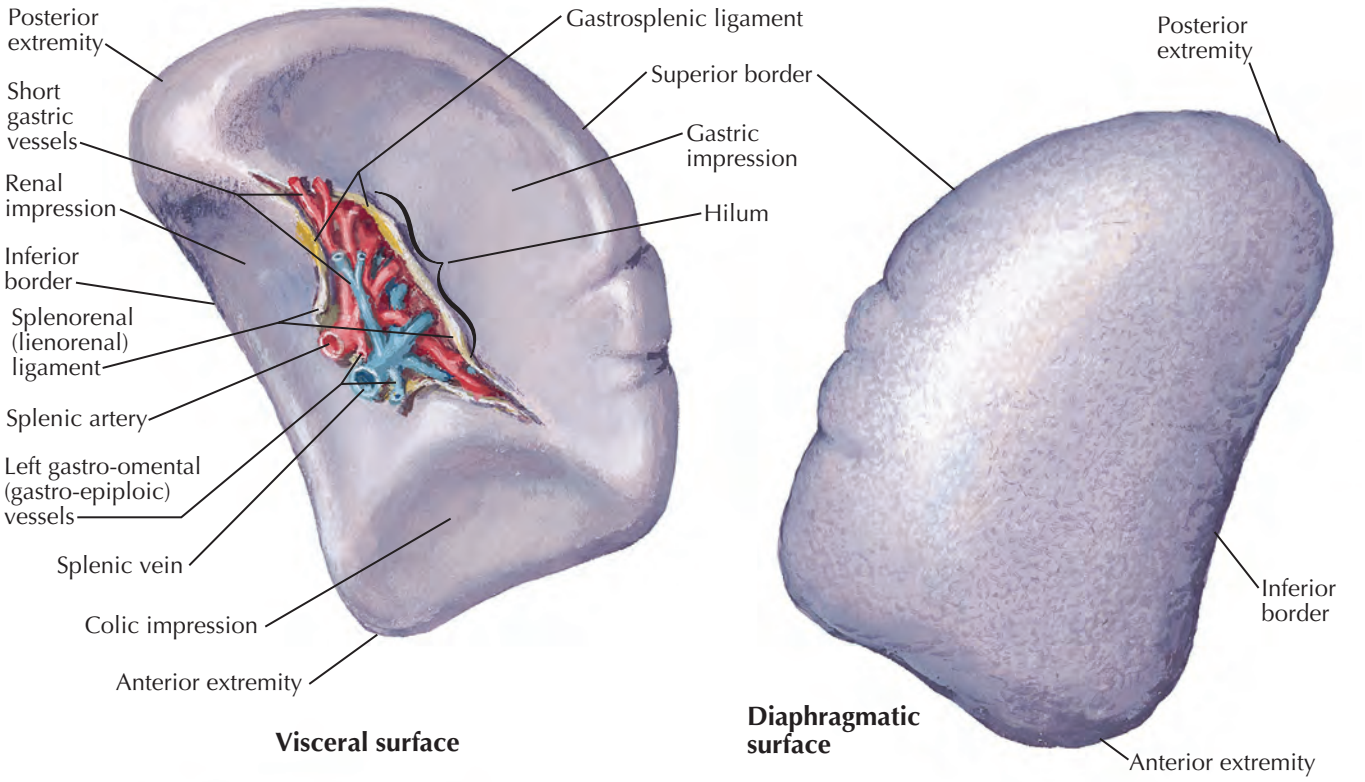

Right and left hepatic ducts
Common hepatic duct
Cystic artery
Cystic duct
Hepatic portal vein
Liver
(Common) bile duct
Gallbladder
Superior (1st) part of duodenum
Transverse colon (cut)
Head of pancreas
Right and left hepatic arteries
Cystohepatic (Calot's) triangle
Hepatic artery proper
Anterior layer of lesser omentum (cut edge)
Right gastric artery
Common hepatic artery
Gastroduodenal artery
Stomach
Hepatic ducts
Right
Left
Cystic duct
Spiral fold
Smooth part
Neck
Infundibulum (Hartmann's pouch)
Body
Fundus
Gallbladder
Common hepatic duct
Gland orifices
(Common) bile duct
Descending (2nd) part of duodenum
Hepatopancreatic ampulla (of Vater)
Major duodenal papilla (of Vater)
Pancreatic duct
Minor duodenal papilla
Circular folds (valves of Kerckring)
Major duodenal papilla
Longitudinal fold
Interior of descending (2nd) part of duodenum
Longitudinal duodenal muscle seen through opening in circular muscle
Reinforcing fibers
Fibers to longitudinal bundle
(Common) bile duct
Longitudinal muscle of duodenum
Circular muscle of duodenum
Pancreatic duct
Sphincter of (common) bile duct
Longitudinal bundle
Sphincter of pancreatic duct (inconstant)
Reinforcing fibers
Duodenal muscle fibers to longitudinal bundle
Sphincter of hepatopancreatic ampulla
Dissection

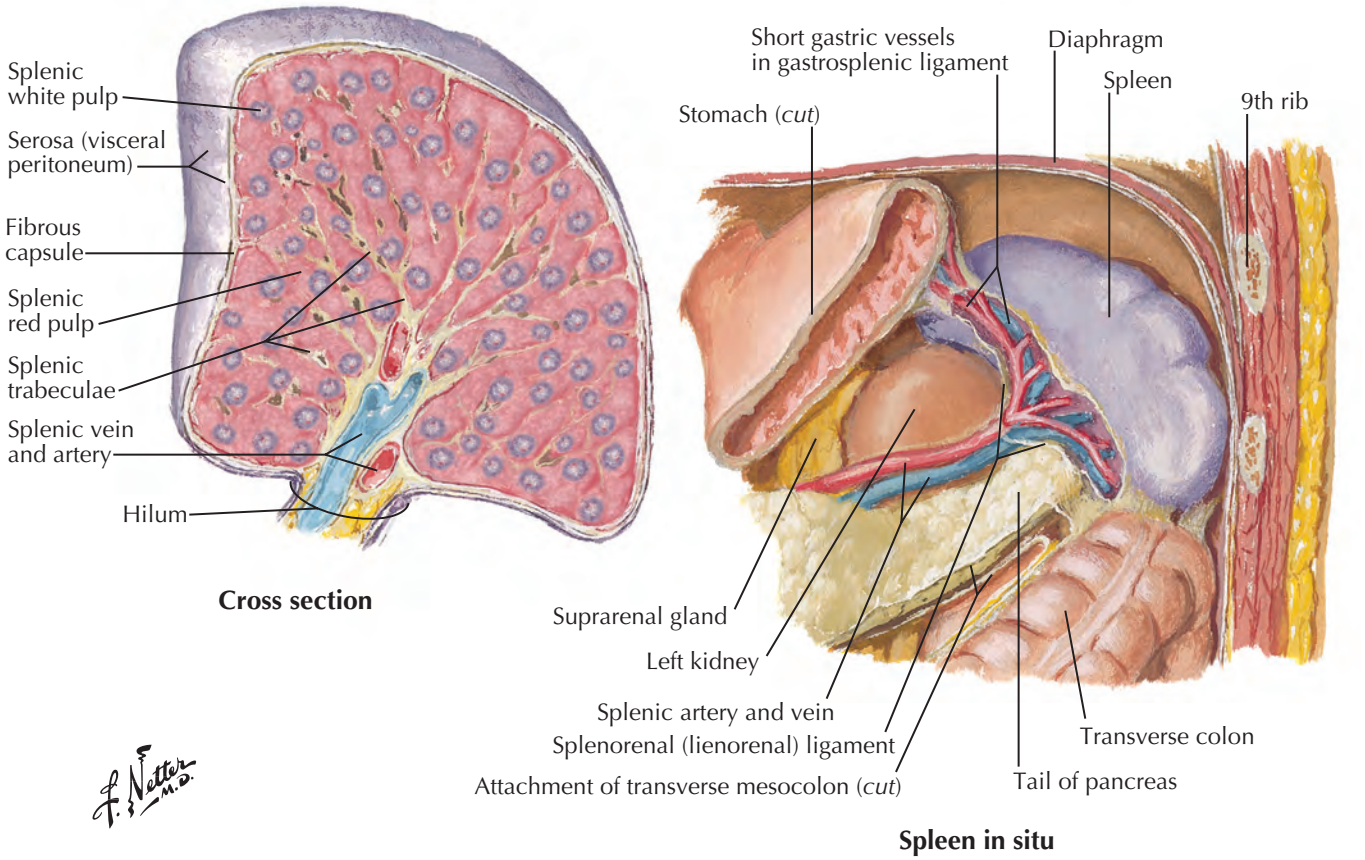


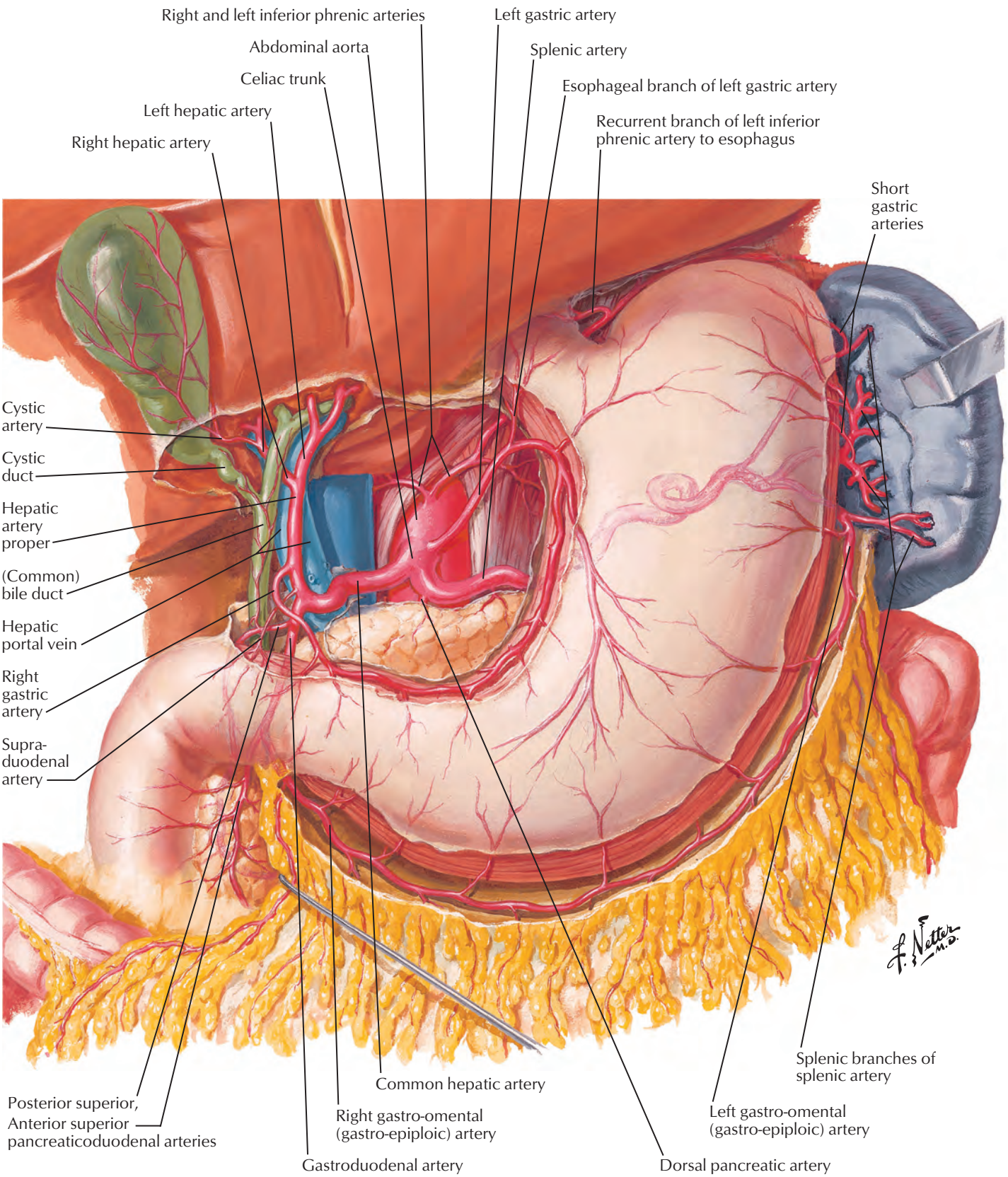
Magnetic resonance cholangiopancreatography (MRCP)

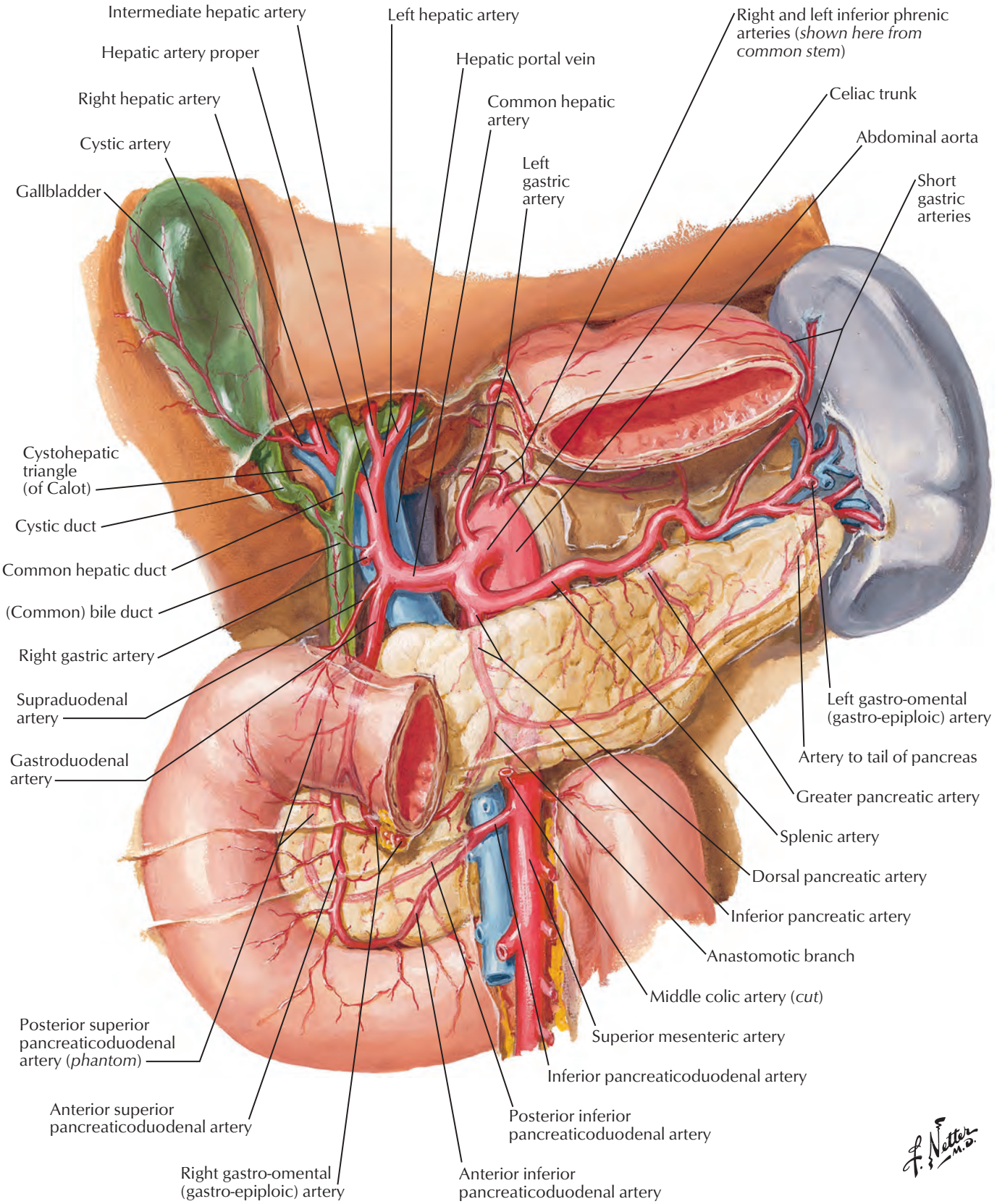





Posterior extremity
Short gastric vessels
Renal impression
Inferior border
Splenorenal (lienorenal) ligament
Splenic artery
Left gastro-omental (gastro-epiploic) vessels
Splenic vein
Colic impression
Anterior extremity
Gastrosplenic ligament
Superior border
Gastric impression
Hilum
Visceral surface
Posterior extremity
Inferior border
Anterior extremity
Diaphragmatic surface

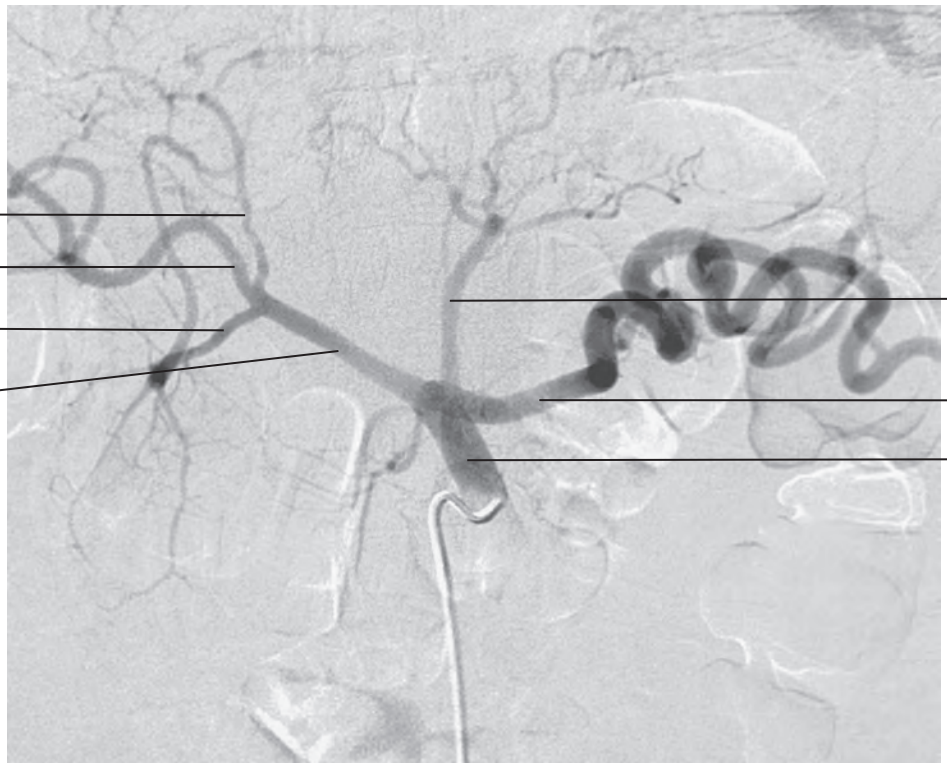

Splenic white pulp
Serosa (visceral peritoneum)
Fibrous capsule
Splenic red pulp
Splenic trabeculae
Splenic vein and artery
Hilum
Cross section
Short gastric vessels in gastrosplenic ligament
Diaphragm
Spleen
9th rib
Stomach (cut)
Suprarenal gland
Left kidney
Splenic artery and vein
Splenorenal (lienorenal) ligament
Attachment of transverse mesocolon (cut)
Transverse colon
Tail of pancreas
Spleen in situ


Right and left inferior phrenic arteries
Left gastric artery
Abdominal aorta
Splenic artery
Celiac trunk
Esophageal branch of left gastric artery
Left hepatic artery
Recurrent branch of left inferior phrenic artery to esophagus
Right hepatic artery
Short gastric arteries
Cystic artery
Cystic duct
Hepatic artery proper
(Common) bile duct
Hepatic portal vein
Right gastric artery
Supra-duodenal artery
Splenic branches of splenic artery
Common hepatic artery
Posterior superior, Anterior superior pancreaticoduodenal arteries
Right gastro-omental (gastro-epiploic) artery
Left gastro-omental (gastro-epiploic) artery
Gastroduodenal artery
Dorsal pancreatic artery

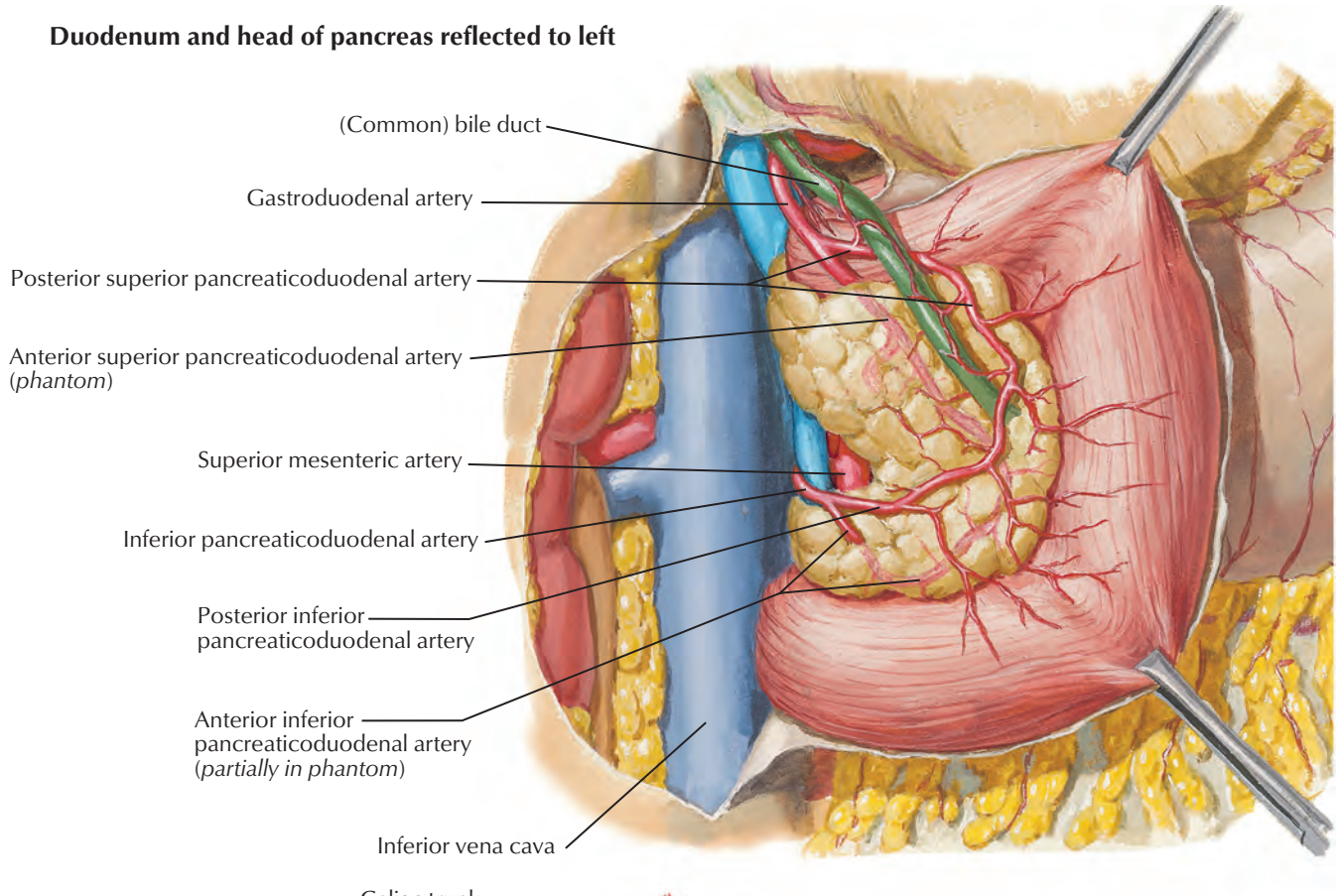

Intermediate hepatic artery
Left hepatic artery
Right and left inferior phrenic arteries (*shown here from common stem*)
Hepatic artery proper
Hepatic portal vein
Right hepatic artery
Common hepatic artery
Celiac trunk
Cystic artery
Abdominal aorta
Left gastric artery
Gallbladder
Short gastric arteries
Cystohepatic triangle (of Calot)
Cystic duct
Common hepatic duct
(Common) bile duct
Right gastric artery
Supraduodenal artery
Left gastro-omental (gastro-epiploic) artery
Gastroduodenal artery
Artery to tail of pancreas
Greater pancreatic artery
Splenic artery
Dorsal pancreatic artery
Inferior pancreatic artery
Anastomotic branch
Middle colic artery (*cut*)
Posterior superior pancreaticoduodenal artery (*phantom*)
Superior mesenteric artery
Inferior pancreaticoduodenal artery
Anterior superior pancreaticoduodenal artery
Posterior inferior pancreaticoduodenal artery
Right gastro-omental (gastro-epiploic) artery
Anterior inferior pancreaticoduodenal artery

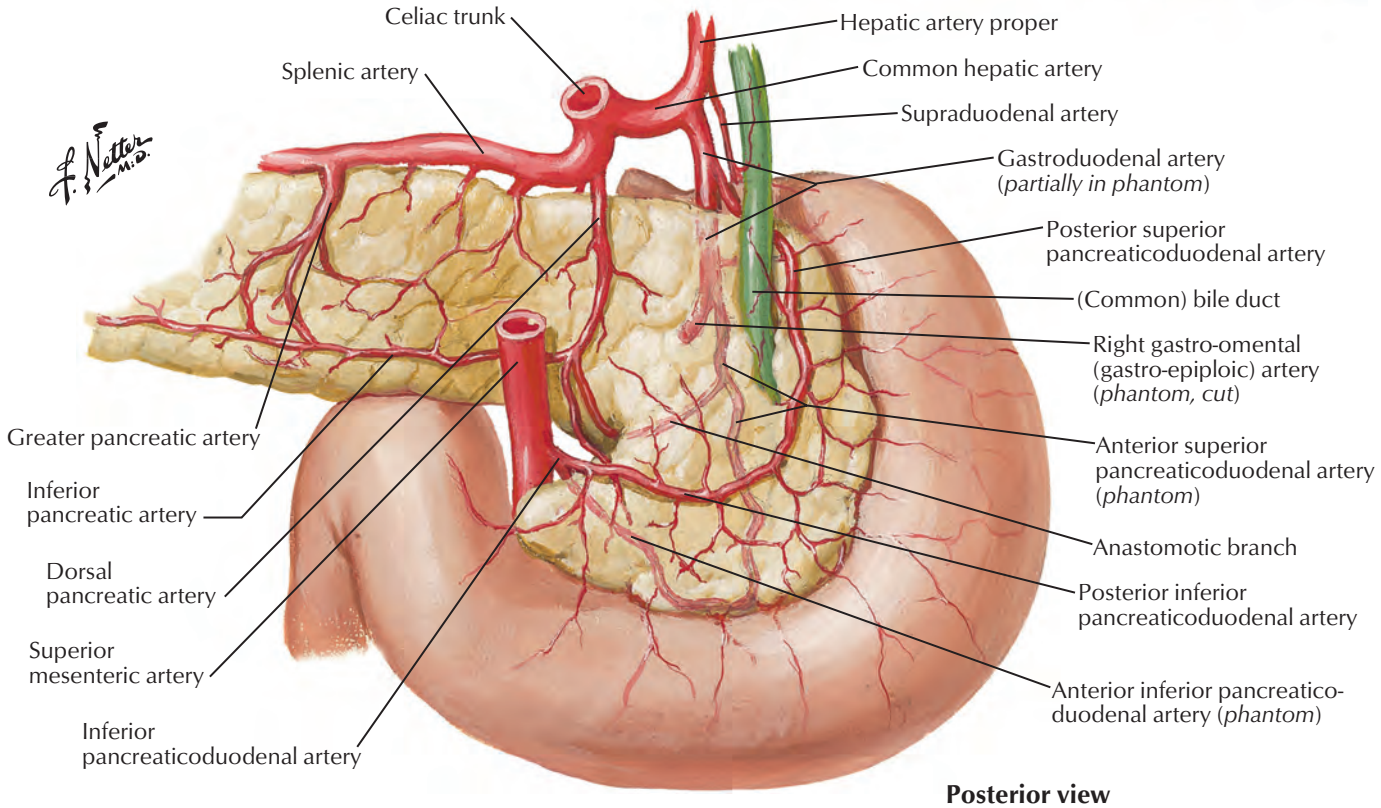
Celiac Arteriogram and CT Angiogram

See also Plates 283, 284

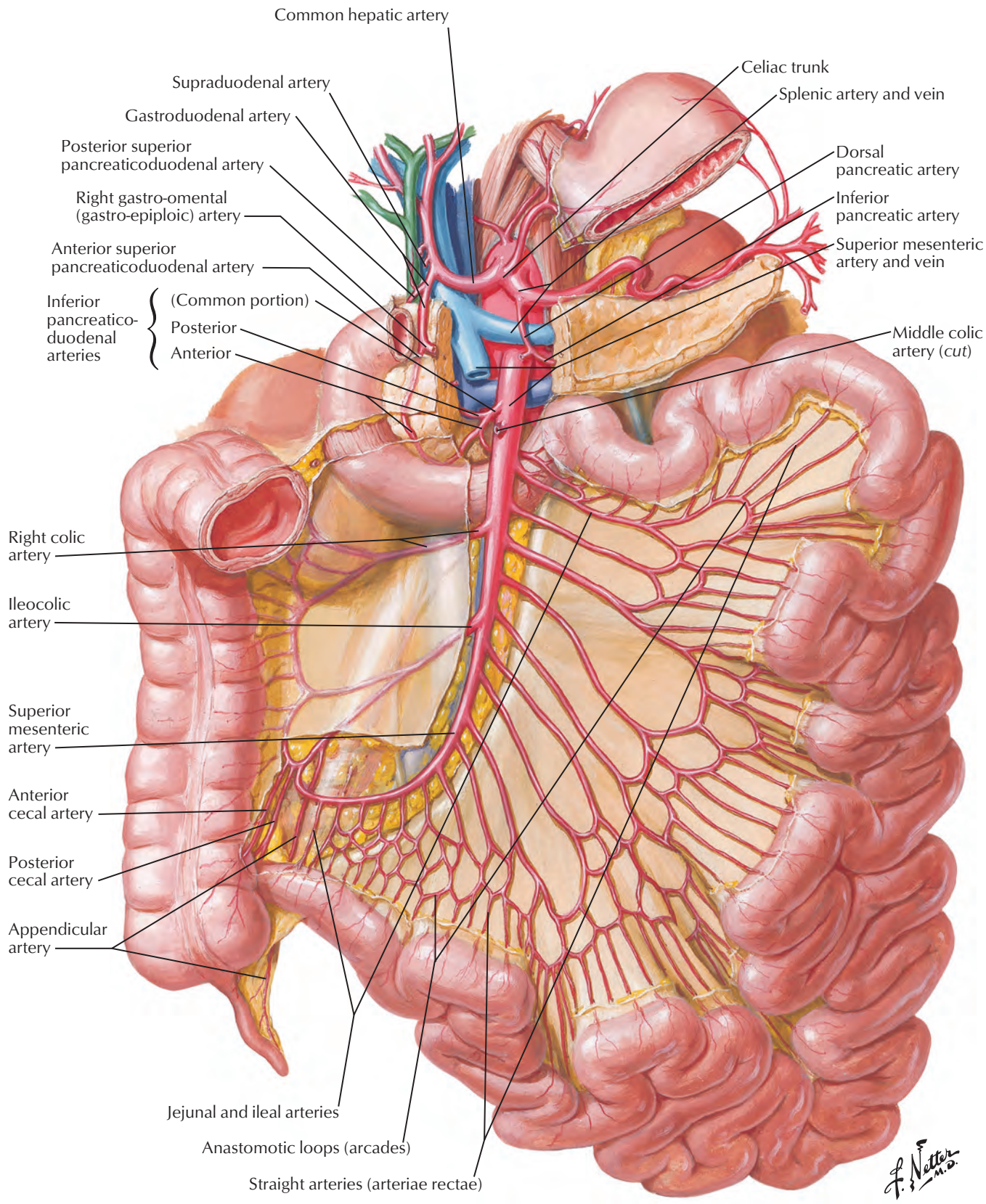


Duodenum and head of pancreas reflected to left



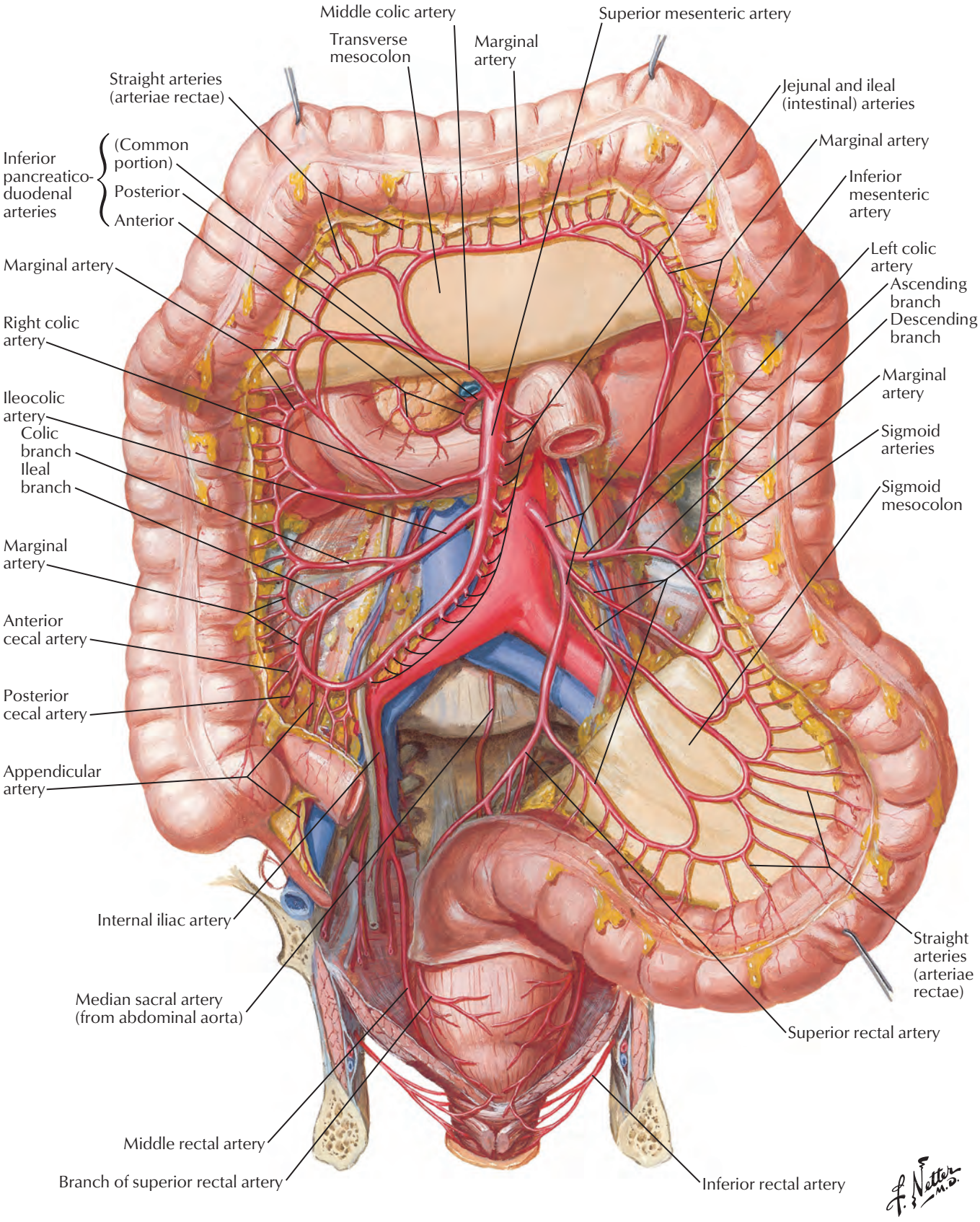


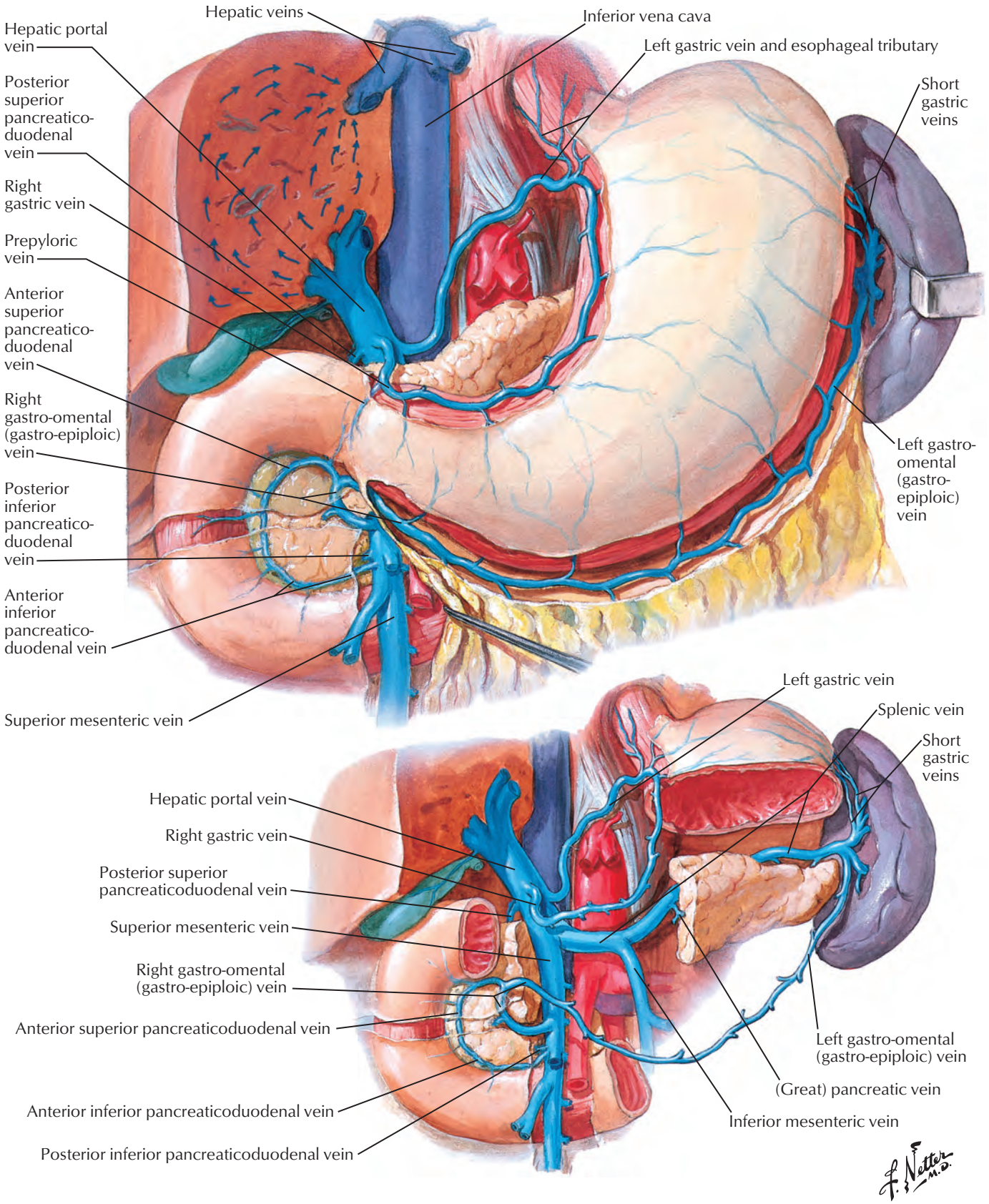
Posterior view

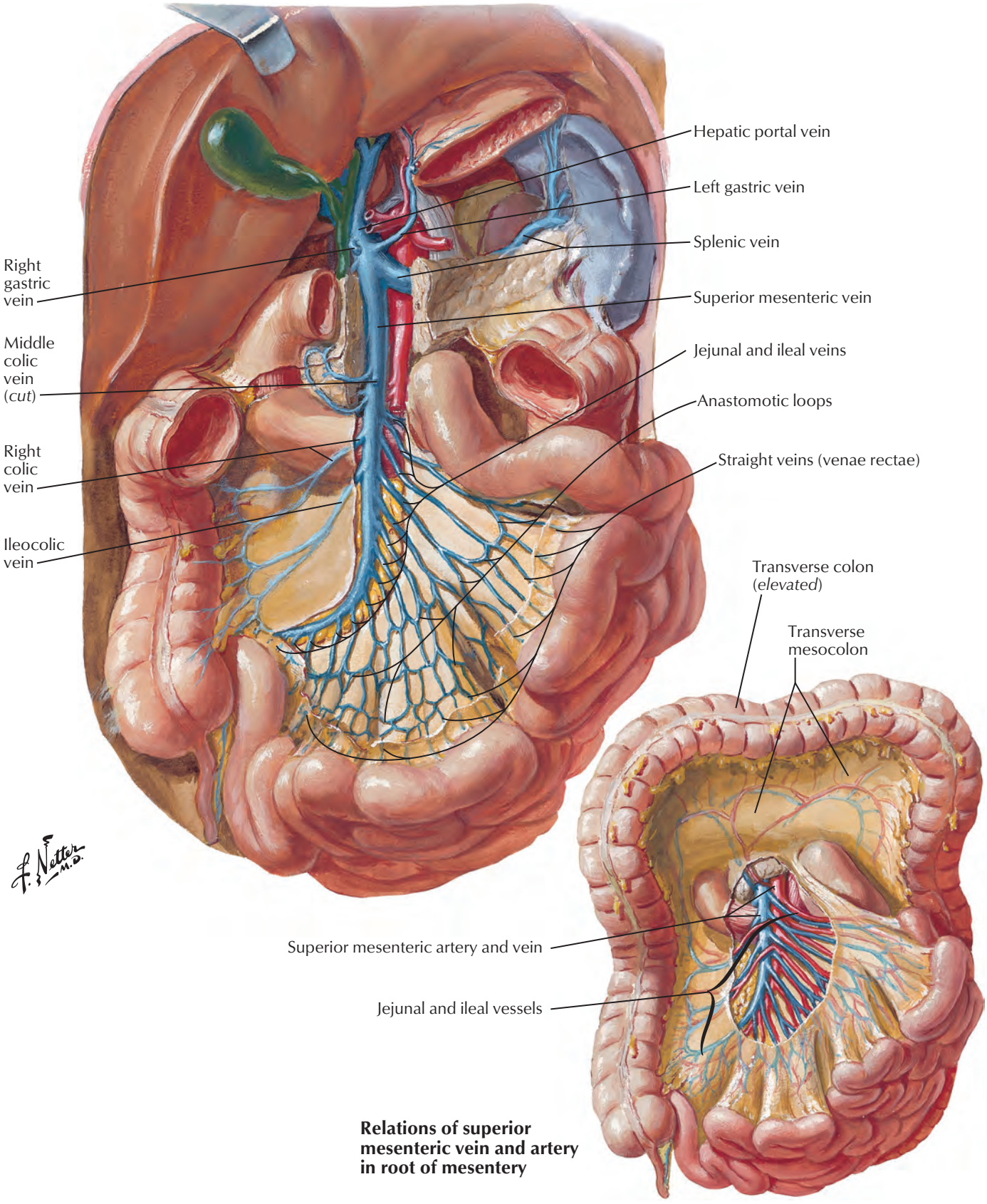

Common hepatic artery
Supraduodenal artery
Gastroduodenal artery
Posterior superior pancreaticoduodenal artery
Right gastro-omental (gastro-epiploic) artery
Anterior superior pancreaticoduodenal artery
Inferior pancreatico-duodenal arteries
(Common portion)
Posterior
Anterior
Celiac trunk
Splenic artery and vein
Dorsal pancreatic artery
Inferior pancreatic artery
Superior mesenteric artery and vein
Middle colic artery (cut)
Right colic artery
Ileocolic artery
Superior mesenteric artery
Anterior cecal artery
Posterior cecal artery
Appendicular artery
Jejunal and ileal arteries
Anastomotic loops (arcades)
Straight arteries (arteriae rectae)

Arteries of Large Intestine

For arteries of rectum see also Plate 376



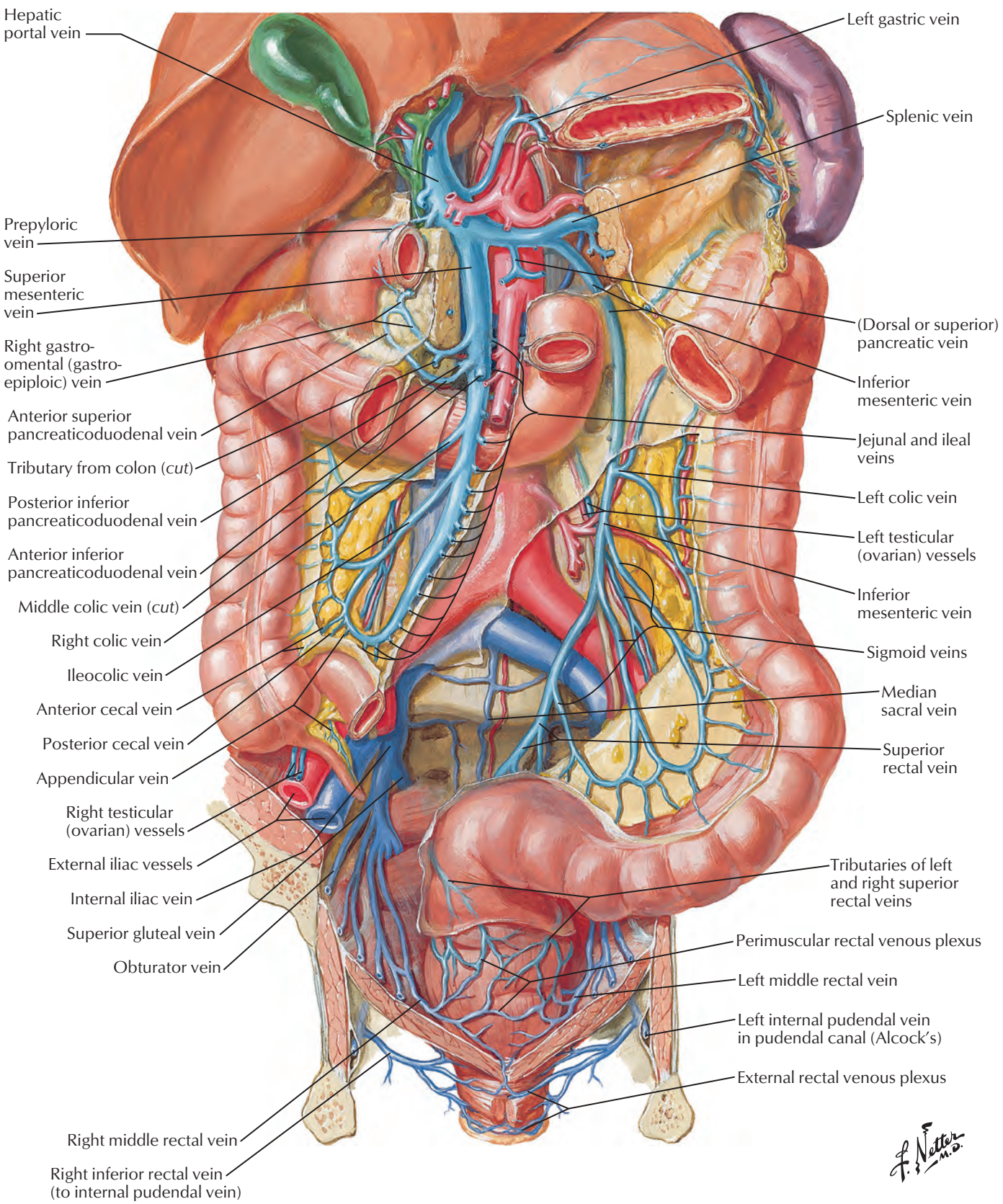

Hepatic veins
Inferior vena cava
Hepatic portal vein
Left gastric vein and esophageal tributary
Posterior superior pancreatico-duodenal vein
Short gastric veins
Right gastric vein
Prepyloric vein
Anterior superior pancreatico-duodenal vein
Right gastro-omental (gastro-epiploic) vein
Left gastro-omental (gastro-epiploic) vein
Posterior inferior pancreatico-duodenal vein
Anterior inferior pancreatico-duodenal vein
Superior mesenteric vein
Left gastric vein
Splenic vein
Short gastric veins
Hepatic portal vein
Right gastric vein
Posterior superior pancreaticoduodenal vein
Superior mesenteric vein
Right gastro-omental (gastro-epiploic) vein
Anterior superior pancreaticoduodenal vein
Left gastro-omental (gastro-epiploic) vein
(Great) pancreatic vein
Anterior inferior pancreaticoduodenal vein
Inferior mesenteric vein
Posterior inferior pancreaticoduodenal vein

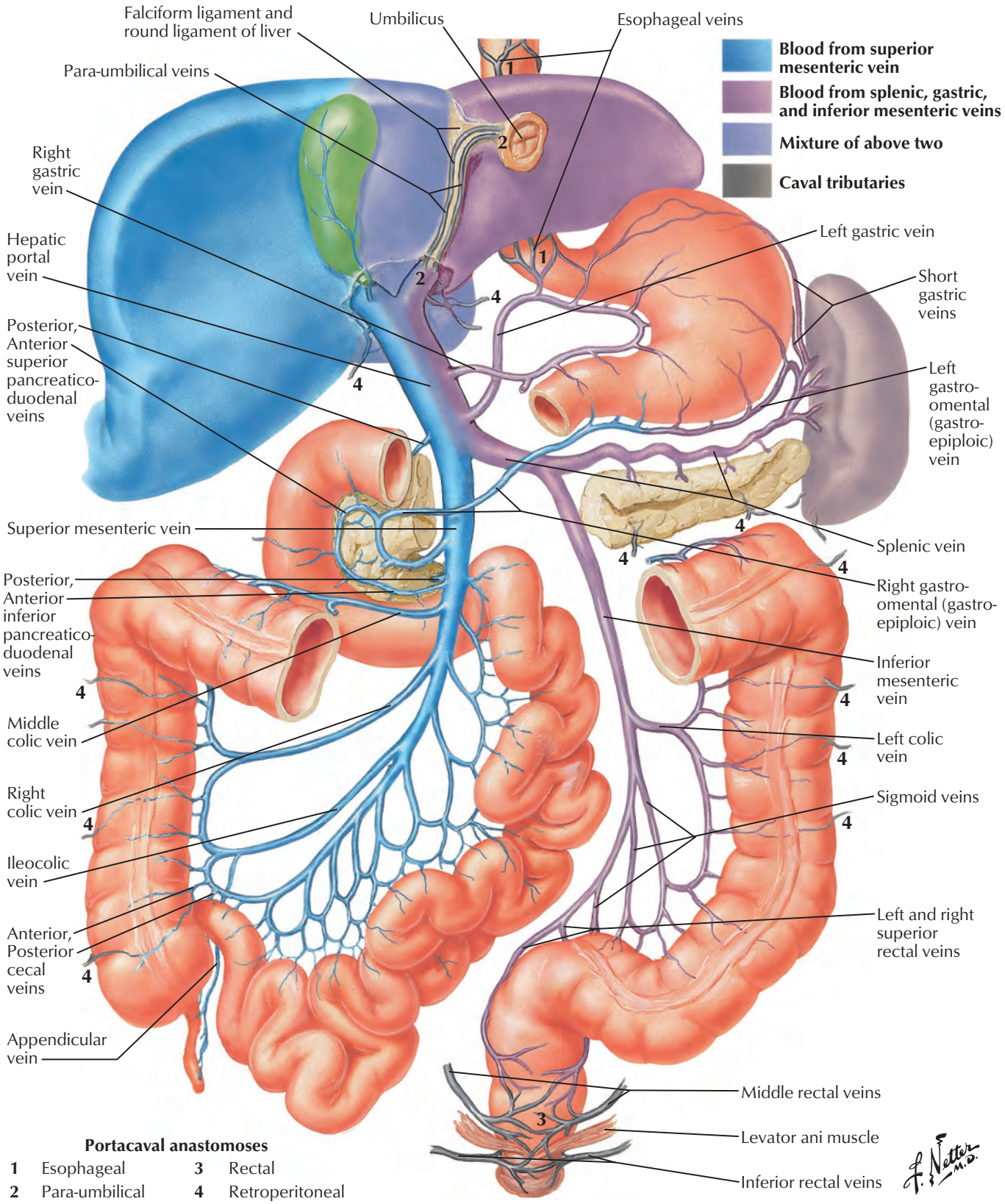


Relations of superior mesenteric vein and artery in root of mesentery

Veins of Large Intestine

For veins of rectum see also Plate 377

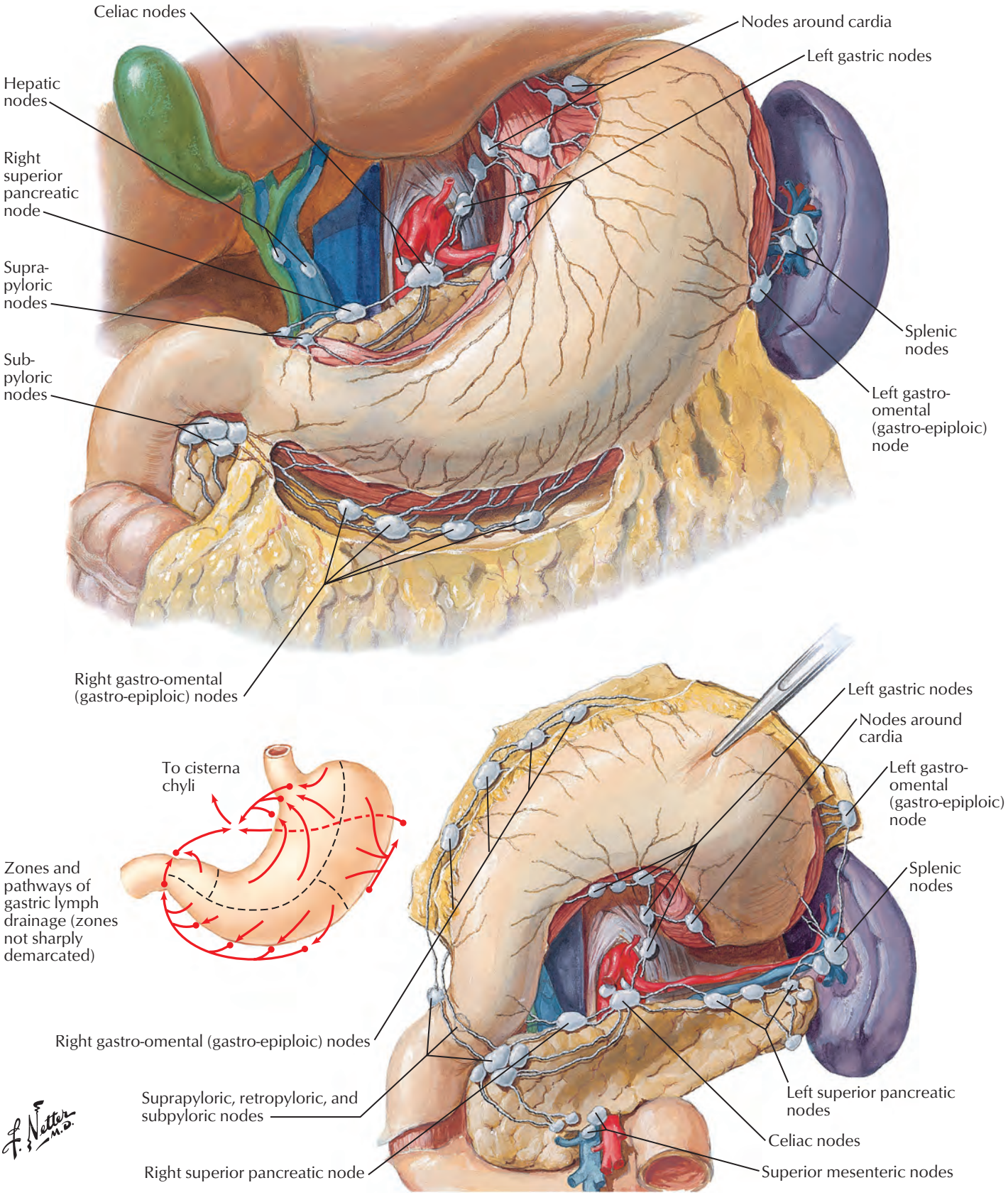


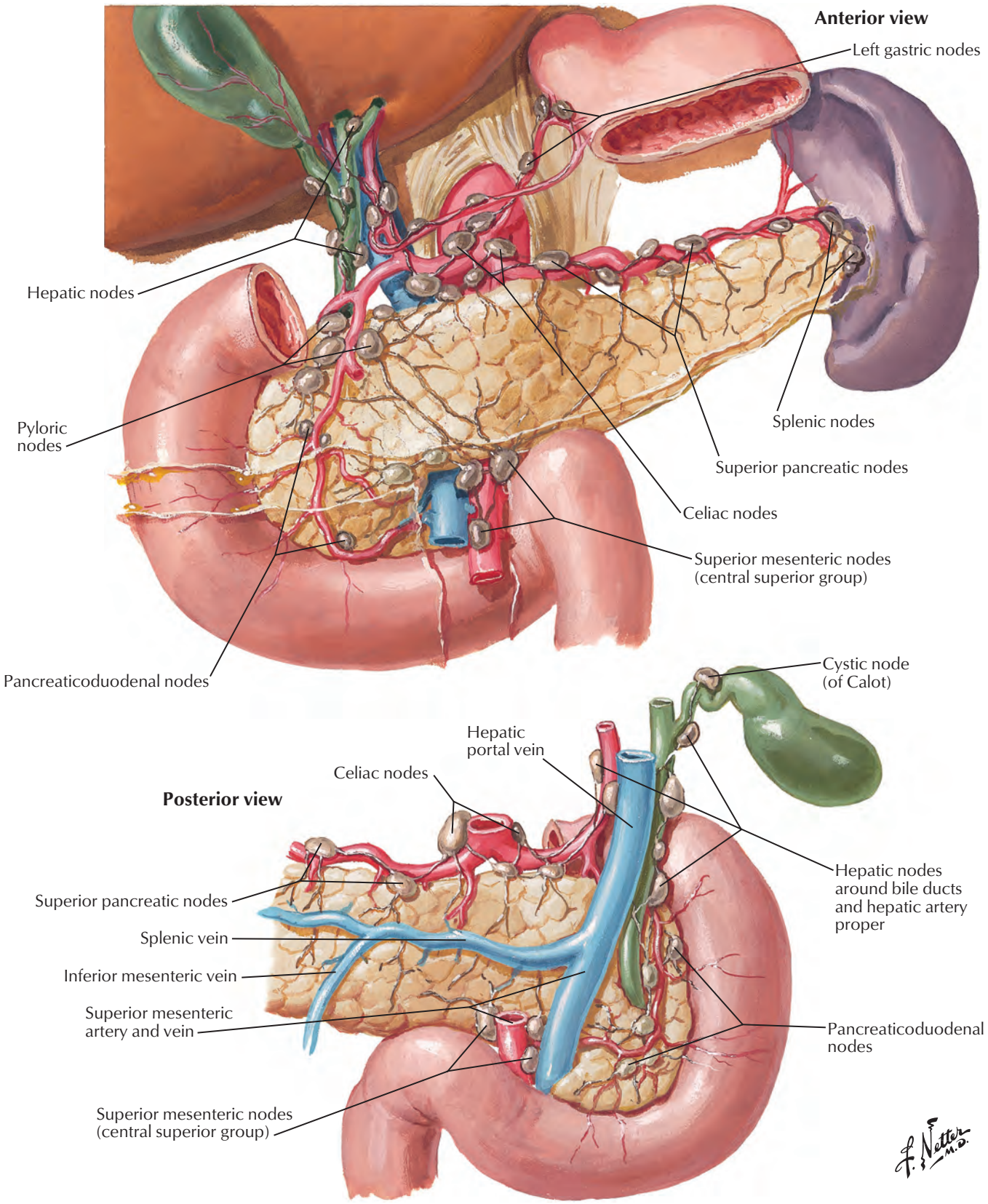


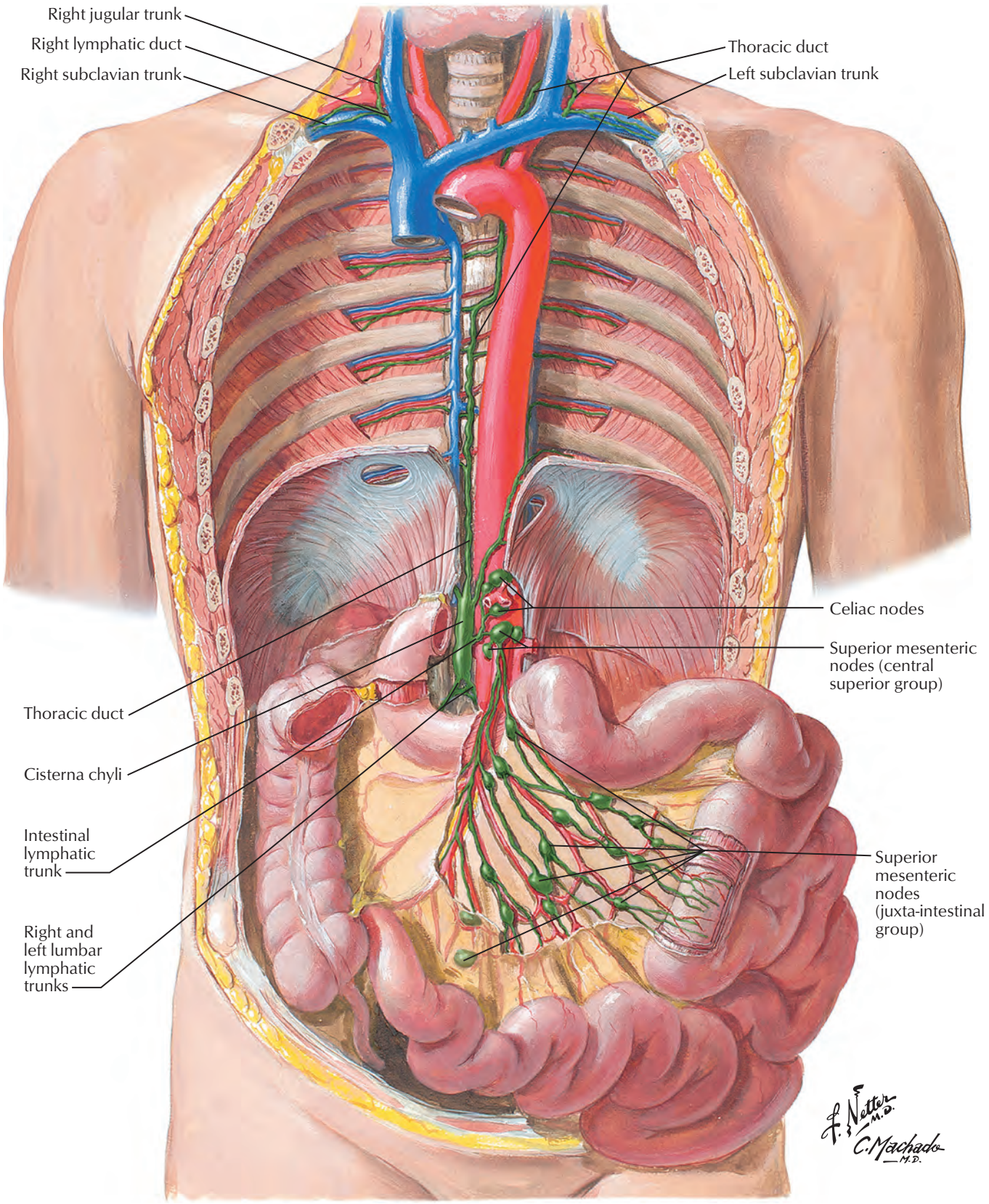
Portacaval anastomoses

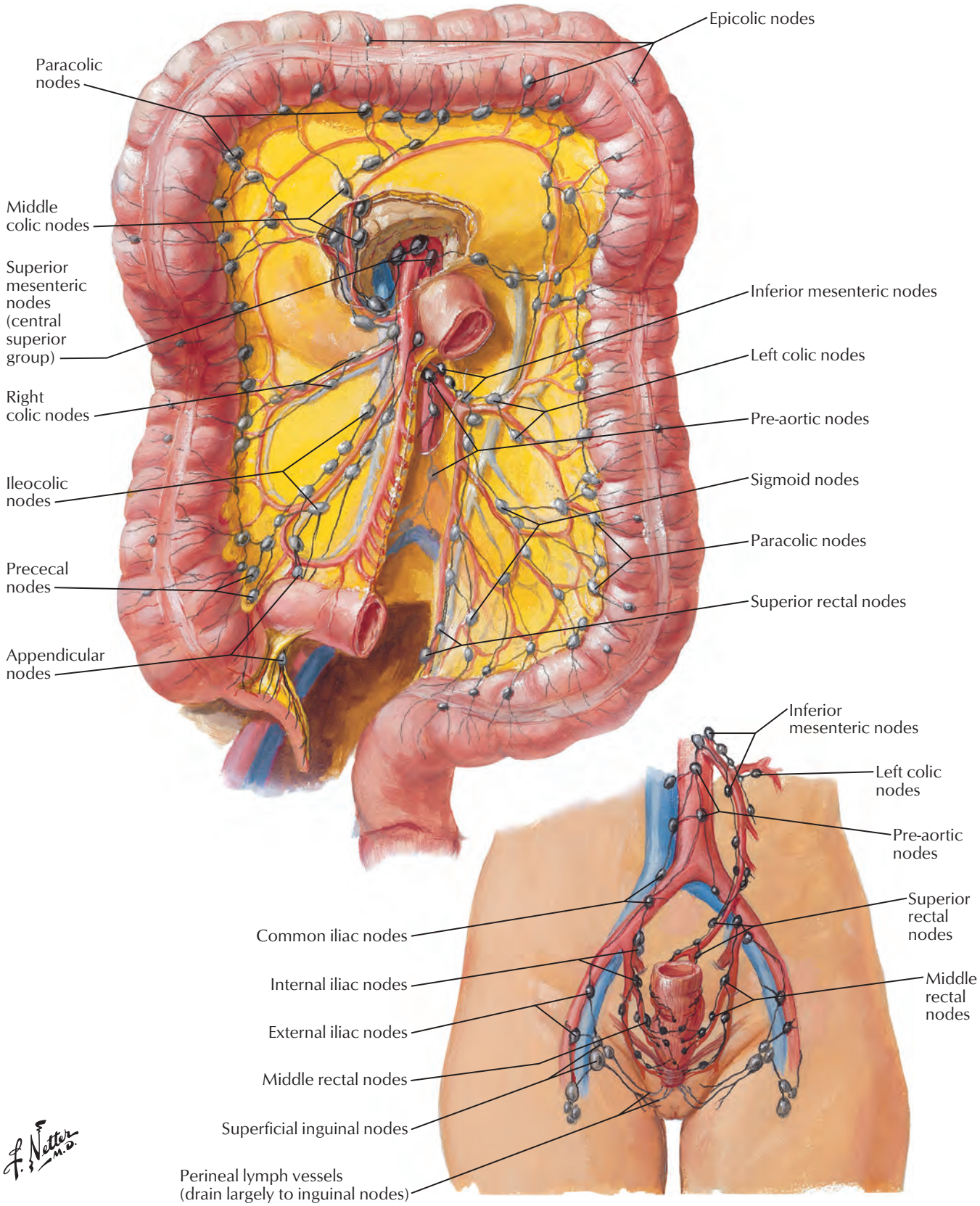
1	Esophageal	**3**	Rectal
2	Para-umbilical	**4**	Retroperitoneal

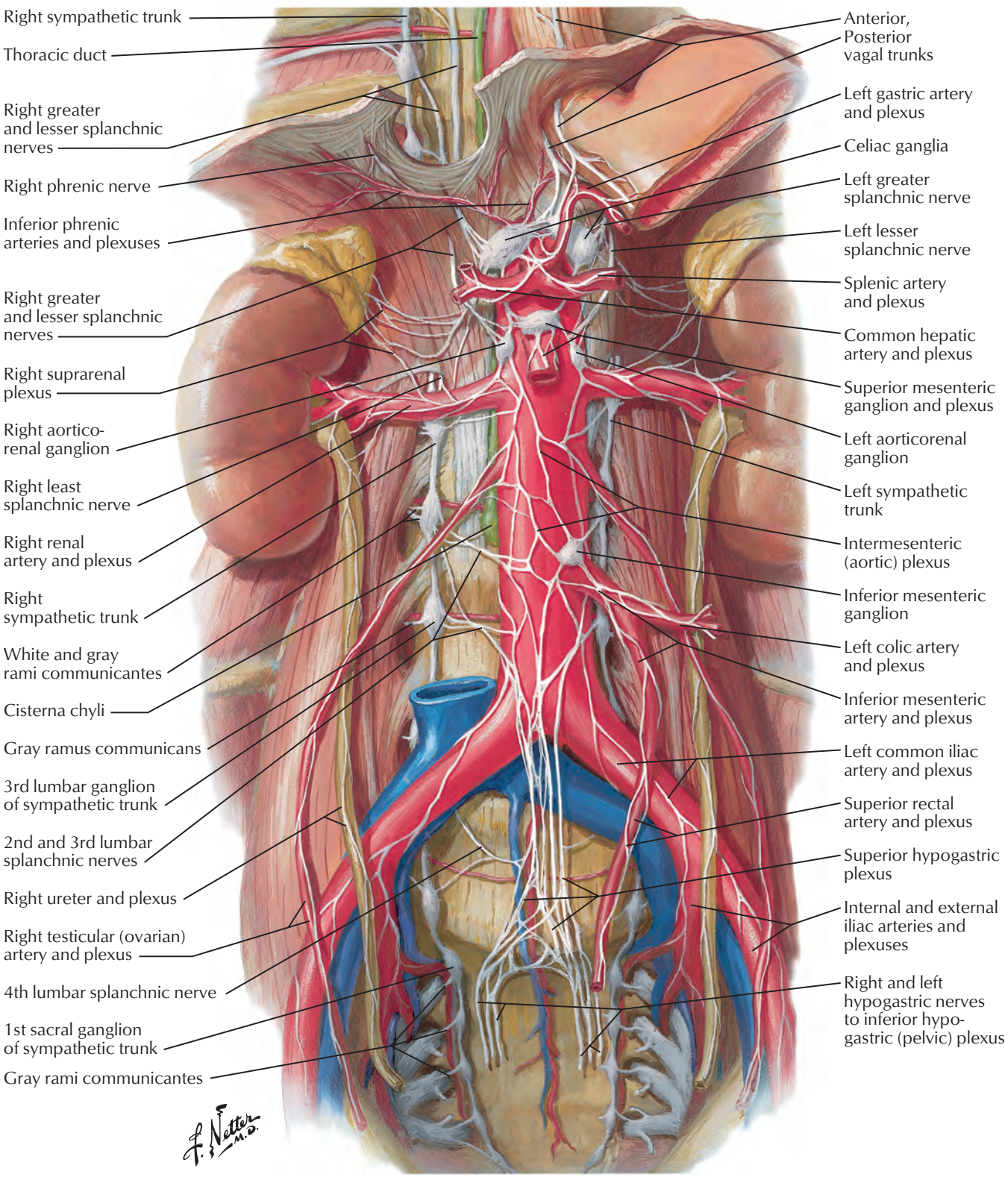
Lymph Vessels and Nodes of Stomach

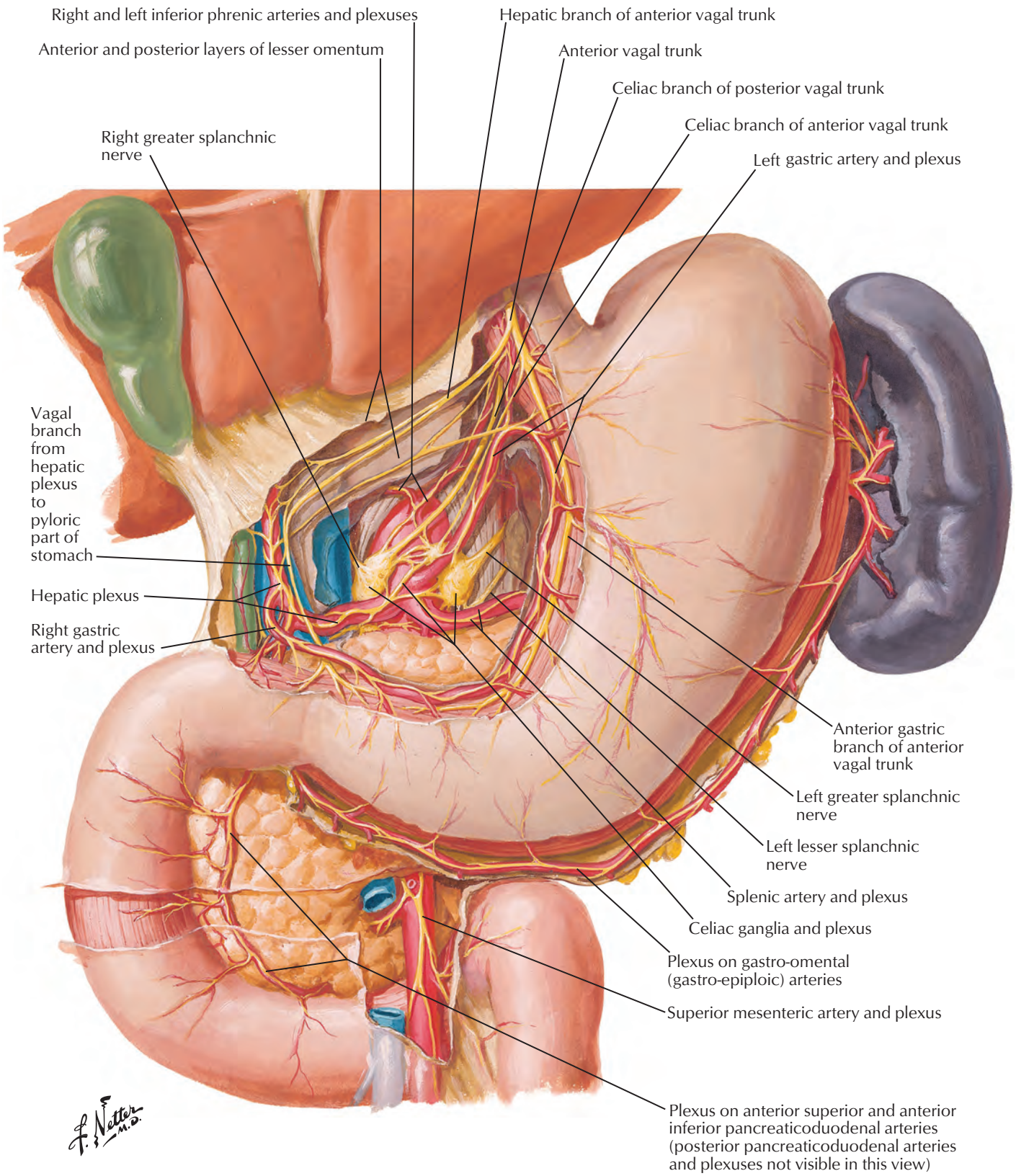


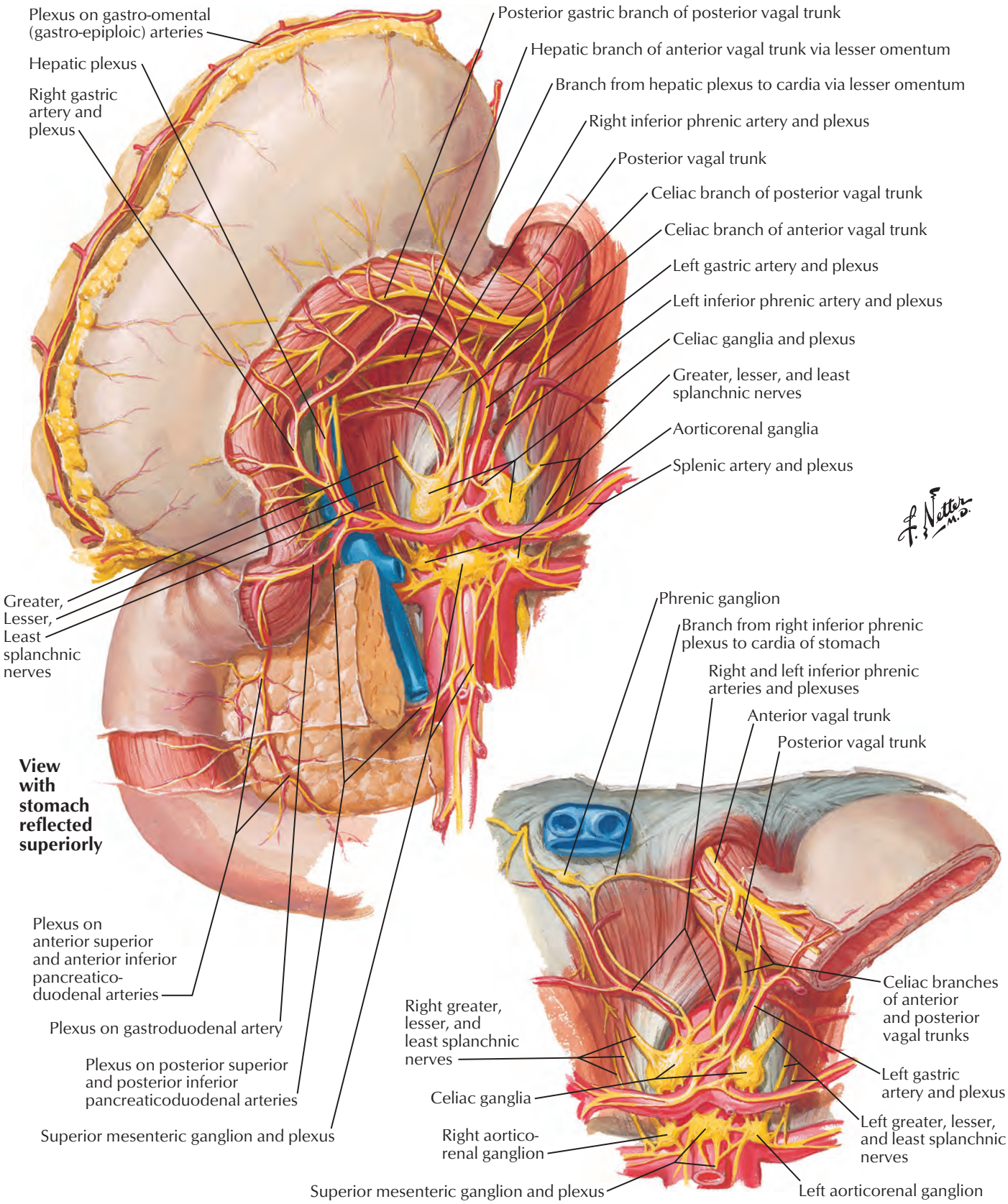

Anterior view
Left gastric nodes
Hepatic nodes
Pyloric nodes
Splenic nodes
Superior pancreatic nodes
Celiac nodes
Superior mesenteric nodes (central superior group)
Pancreaticoduodenal nodes
Cystic node (of Calot)
Hepatic portal vein
Celiac nodes
Posterior view
Hepatic nodes around bile ducts and hepatic artery proper
Superior pancreatic nodes
Splenic vein
Inferior mesenteric vein
Superior mesenteric artery and vein
Pancreaticoduodenal nodes
Superior mesenteric nodes (central superior group)


Right jugular trunk
Right lymphatic duct
Right subclavian trunk
Thoracic duct
Left subclavian trunk
Celiac nodes
Superior mesenteric nodes (central superior group)
Thoracic duct
Cisterna chyli
Intestinal lymphatic trunk
Right and left lumbar lymphatic trunks
Superior mesenteric nodes (juxta-intestinal group)
F. Netter M.D.
C. Machado M.D.


Epicolic nodes
Paracolic nodes
Middle colic nodes
Superior mesenteric nodes (central superior group)
Right colic nodes
Ileocolic nodes
Prececal nodes
Appendicular nodes
Inferior mesenteric nodes
Left colic nodes
Pre-aortic nodes
Sigmoid nodes
Paracolic nodes
Superior rectal nodes
Inferior mesenteric nodes
Left colic nodes
Pre-aortic nodes
Superior rectal nodes
Middle rectal nodes
Common iliac nodes
Internal iliac nodes
External iliac nodes
Middle rectal nodes
Superficial inguinal nodes
Perineal lymph vessels (drain largely to inguinal nodes)

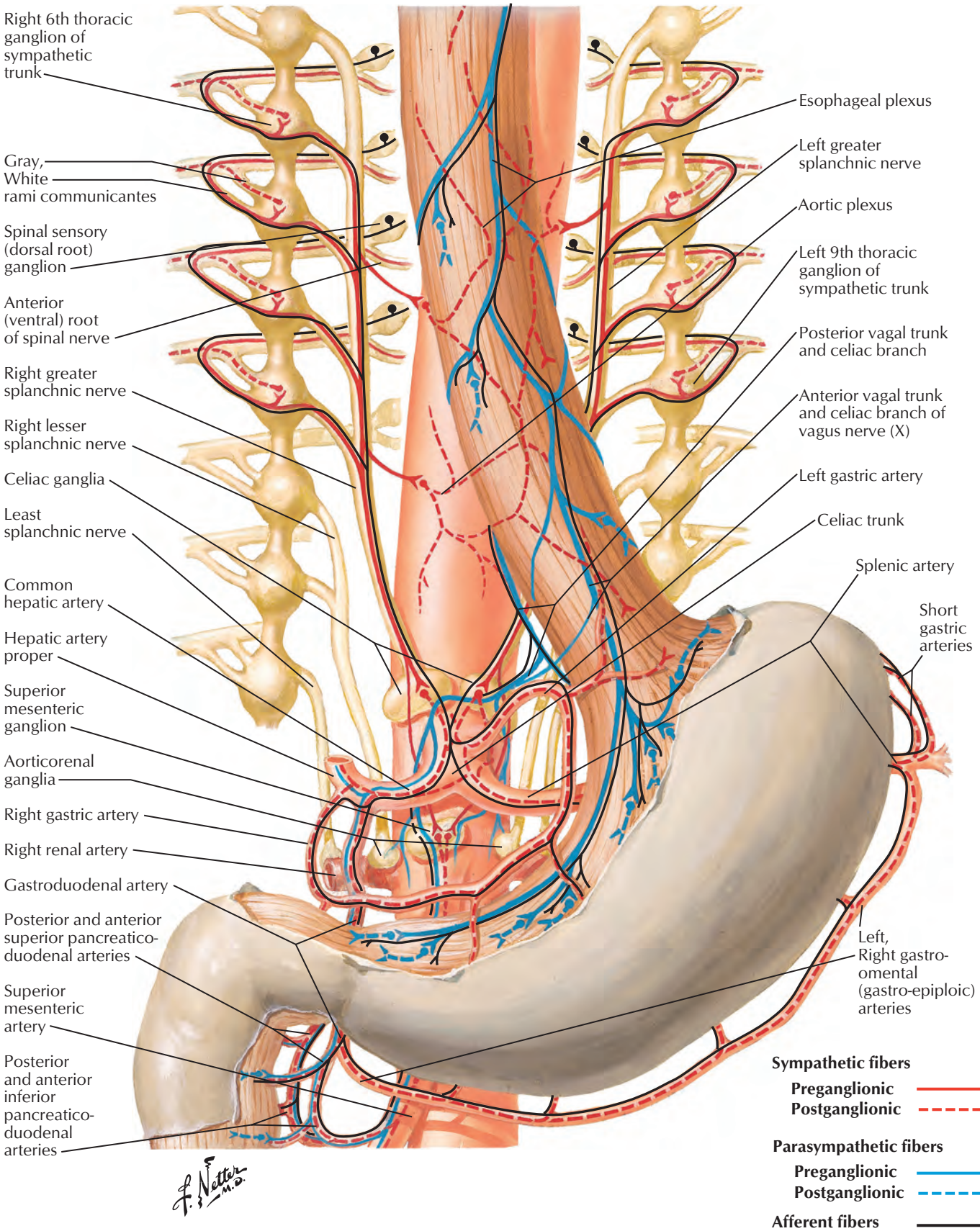

Right sympathetic trunk
Thoracic duct
Right greater and lesser splanchnic nerves
Right phrenic nerve
Inferior phrenic arteries and plexuses
Right greater and lesser splanchnic nerves
Right suprarenal plexus
Right aortico-renal ganglion
Right least splanchnic nerve
Right renal artery and plexus
Right sympathetic trunk
White and gray rami communicantes
Cisterna chyli
Gray ramus communicans
3rd lumbar ganglion of sympathetic trunk
2nd and 3rd lumbar splanchnic nerves
Right ureter and plexus
Right testicular (ovarian) artery and plexus
4th lumbar splanchnic nerve
1st sacral ganglion of sympathetic trunk
Gray rami communicantes
Anterior, Posterior vagal trunks
Left gastric artery and plexus
Celiac ganglia
Left greater splanchnic nerve
Left lesser splanchnic nerve
Splenic artery and plexus
Common hepatic artery and plexus
Superior mesenteric ganglion and plexus
Left aorticorenal ganglion
Left sympathetic trunk
Intermesenteric (aortic) plexus
Inferior mesenteric ganglion
Left colic artery and plexus
Inferior mesenteric artery and plexus
Left common iliac artery and plexus
Superior rectal artery and plexus
Superior hypogastric plexus
Internal and external iliac arteries and plexuses
Right and left hypogastric nerves to inferior hypo-gastric (pelvic) plexus


Right and left inferior phrenic arteries and plexuses
Anterior and posterior layers of lesser omentum
Right greater splanchnic nerve
Hepatic branch of anterior vagal trunk
Anterior vagal trunk
Celiac branch of posterior vagal trunk
Celiac branch of anterior vagal trunk
Left gastric artery and plexus
Vagal branch from hepatic plexus to pyloric part of stomach
Hepatic plexus
Right gastric artery and plexus
Anterior gastric branch of anterior vagal trunk
Left greater splanchnic nerve
Left lesser splanchnic nerve
Splenic artery and plexus
Celiac ganglia and plexus
Plexus on gastro-omental (gastro-epiploic) arteries
Superior mesenteric artery and plexus
Plexus on anterior superior and anterior inferior pancreaticoduodenal arteries (posterior pancreaticoduodenal arteries and plexuses not visible in this view)

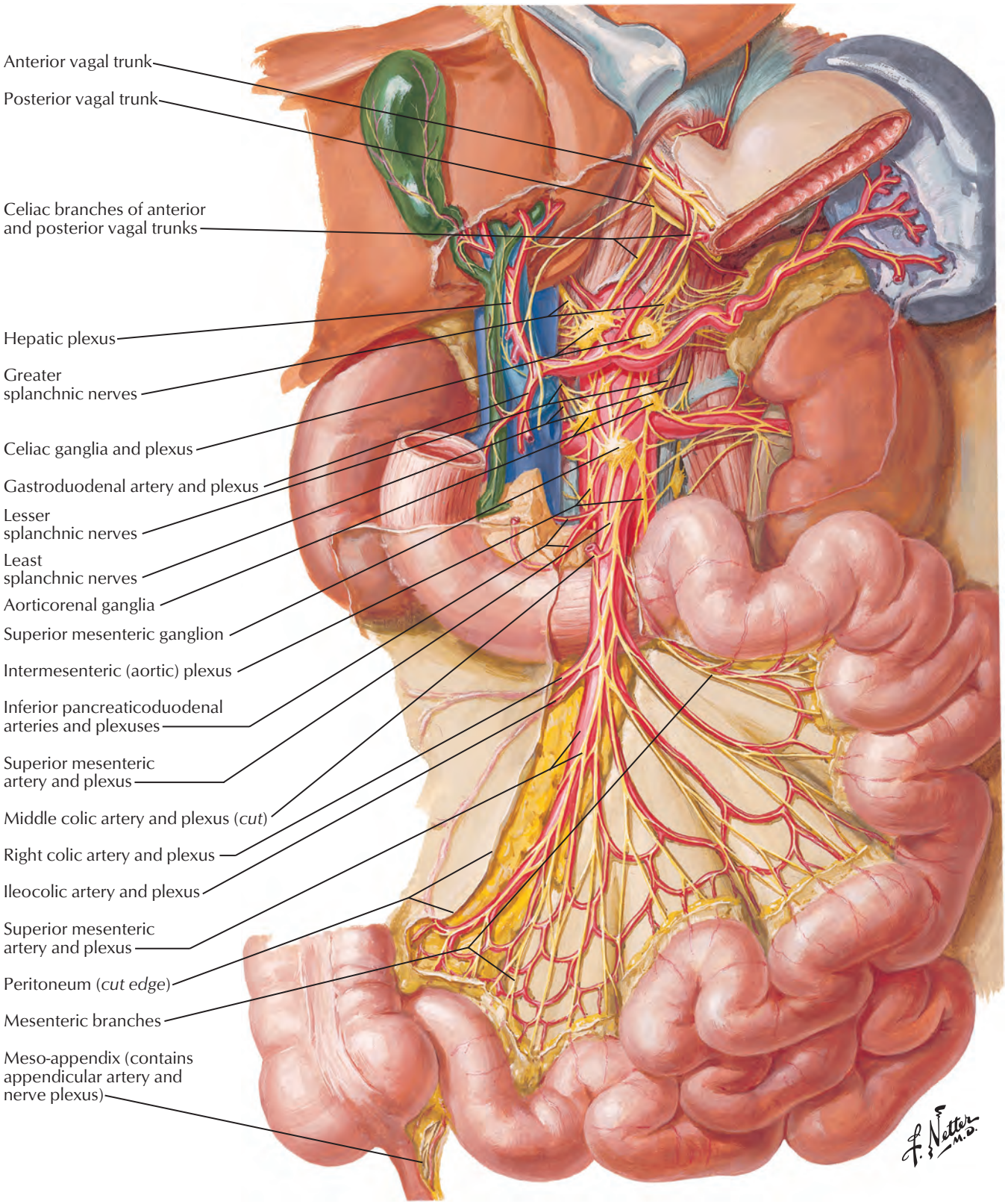

Plexus on gastro-omental (gastro-epiploic) arteries
Hepatic plexus
Right gastric artery and plexus
Posterior gastric branch of posterior vagal trunk
Hepatic branch of anterior vagal trunk via lesser omentum
Branch from hepatic plexus to cardia via lesser omentum
Right inferior phrenic artery and plexus
Posterior vagal trunk
Celiac branch of posterior vagal trunk
Celiac branch of anterior vagal trunk
Left gastric artery and plexus
Left inferior phrenic artery and plexus
Celiac ganglia and plexus
Greater, lesser, and least splanchnic nerves
Aorticorenal ganglia
Splenic artery and plexus
Greater, Lesser, Least splanchnic nerves
View with stomach reflected superiorly
Plexus on anterior superior and anterior inferior pancreatico-duodenal arteries
Plexus on gastroduodenal artery
Plexus on posterior superior and posterior inferior pancreaticoduodenal arteries
Superior mesenteric ganglion and plexus
Phrenic ganglion
Branch from right inferior phrenic plexus to cardia of stomach
Right and left inferior phrenic arteries and plexuses
Anterior vagal trunk
Posterior vagal trunk
Celiac branches of anterior and posterior vagal trunks
Right greater, lesser, and least splanchnic nerves
Left gastric artery and plexus
Celiac ganglia
Left greater, lesser, and least splanchnic nerves
Right aortico-renal ganglion
Superior mesenteric ganglion and plexus
Left aorticorenal ganglion

Autonomic Innervation of Stomach and Duodenum: Schema

See also **Plates 163, 164**

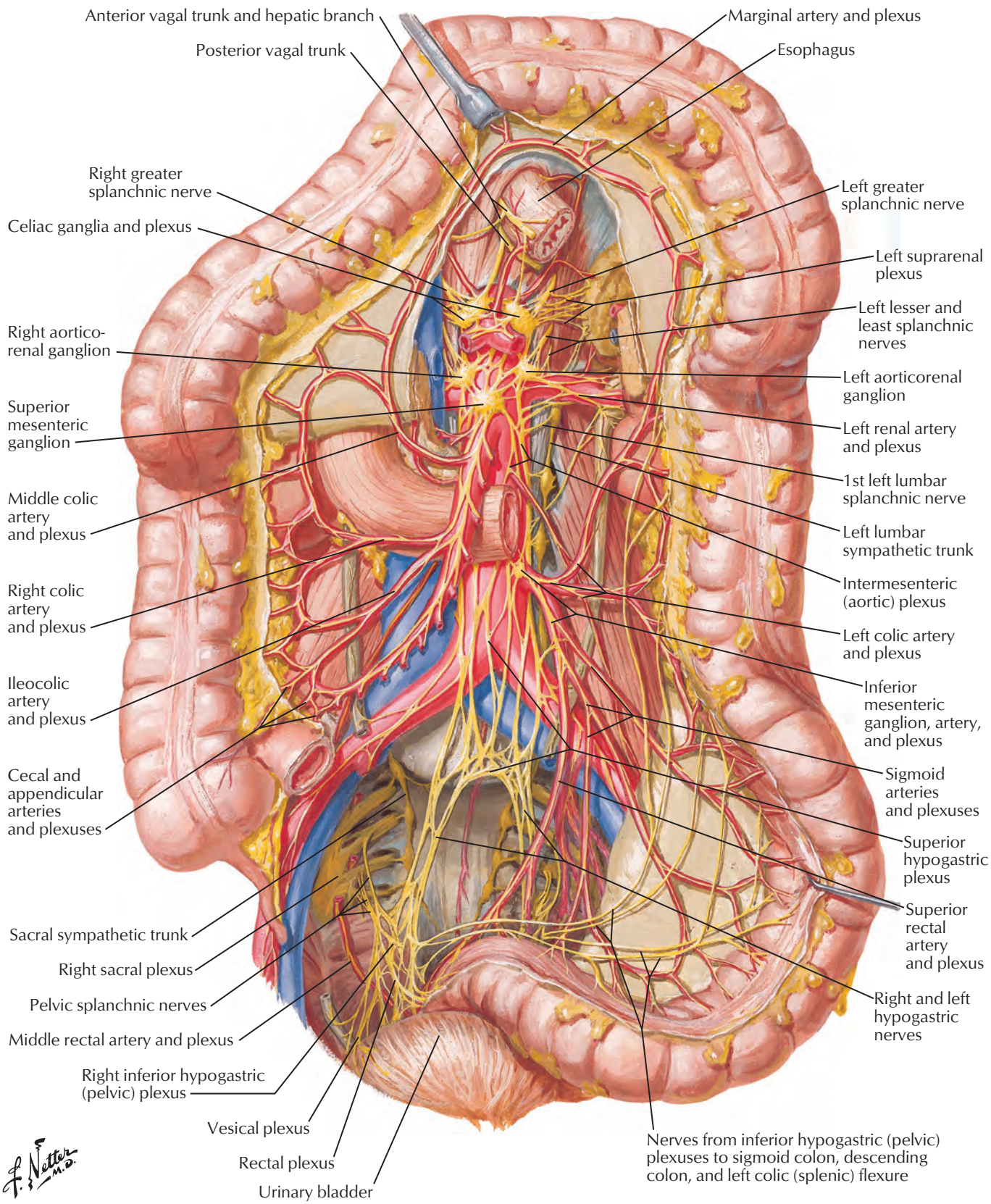


Autonomic Innervation of Small Intestine

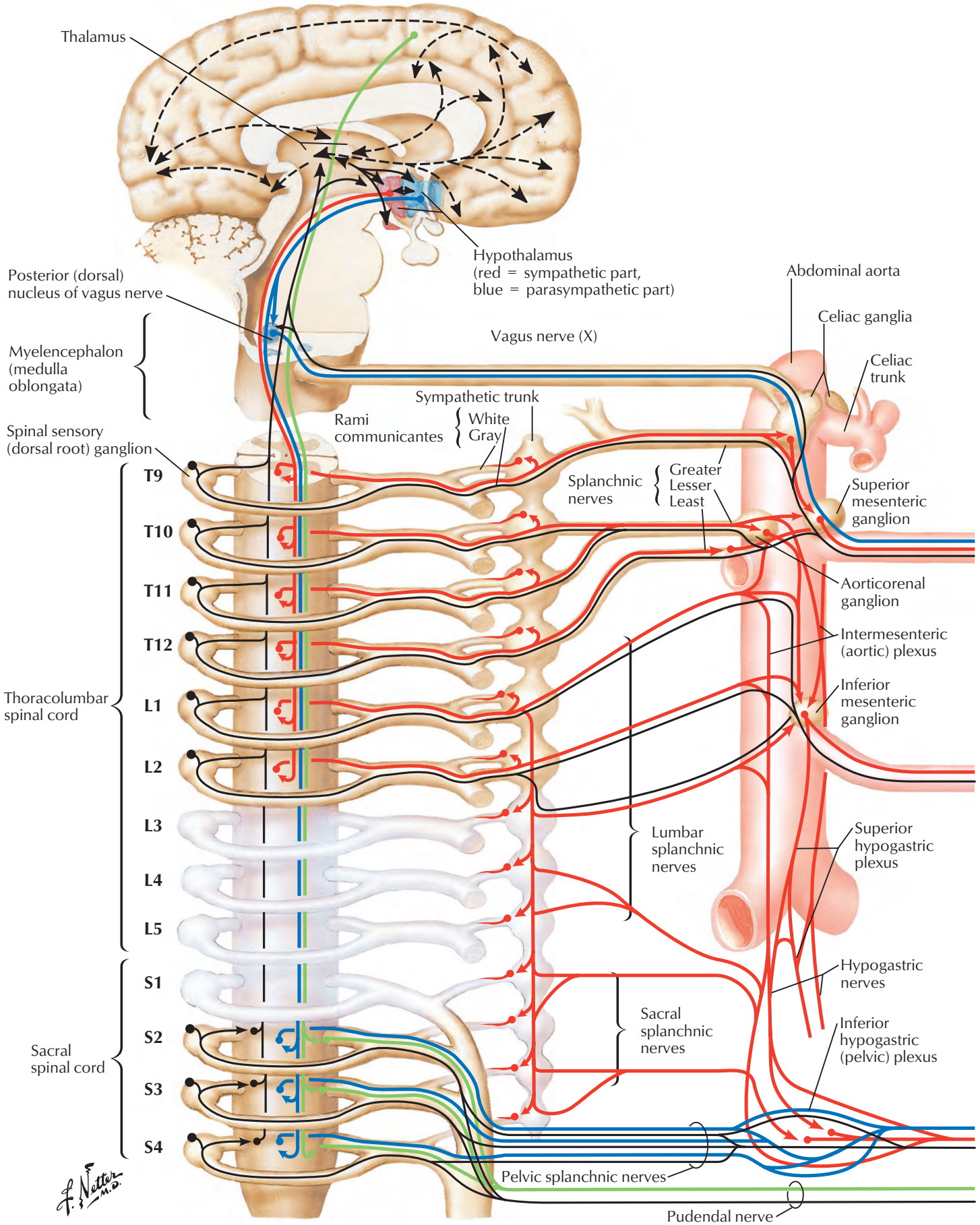


Autonomic Innervation of Large Intestine

For nerves of rectum see Plates 388–391

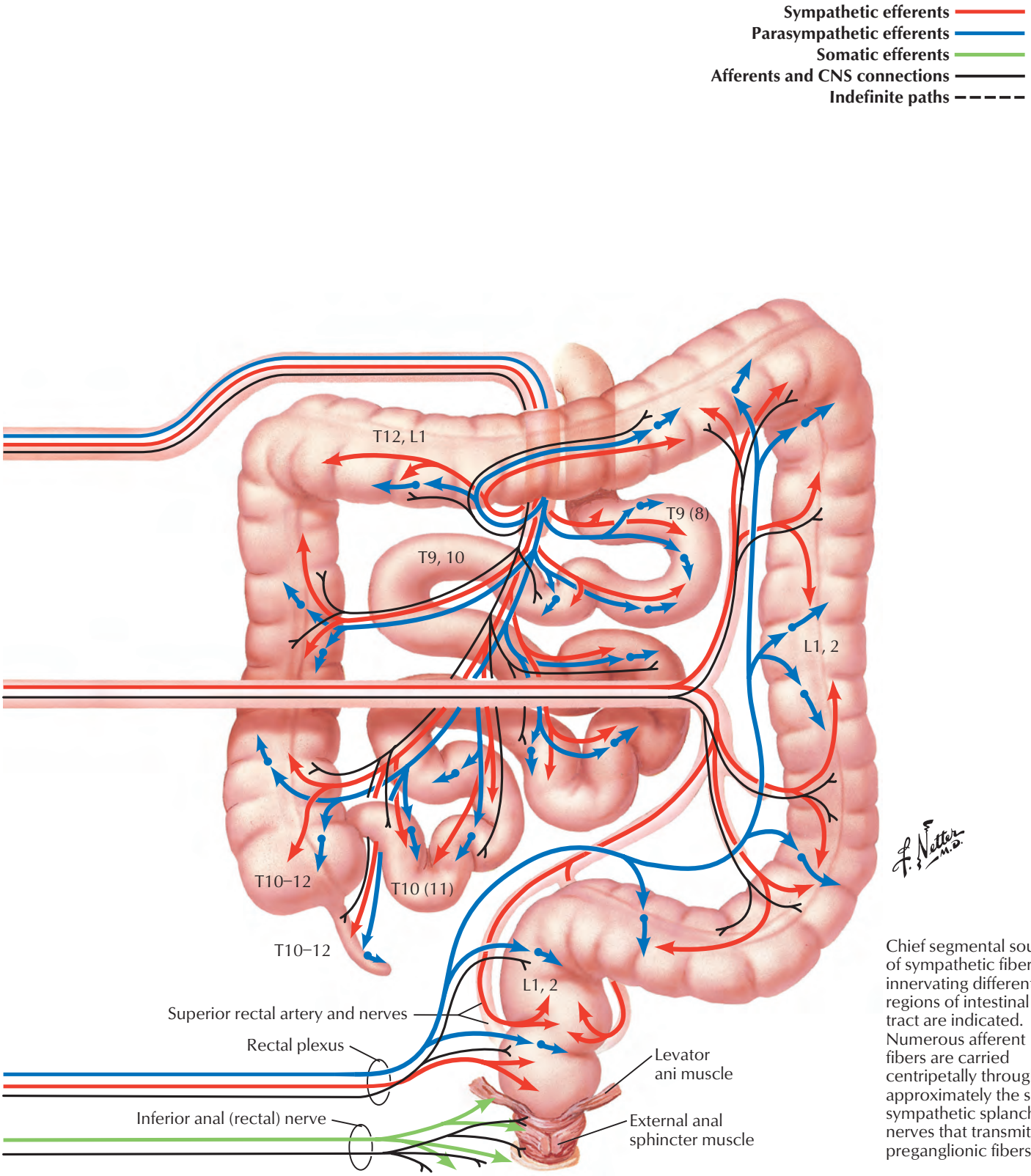


See also **Plates 163, 164**



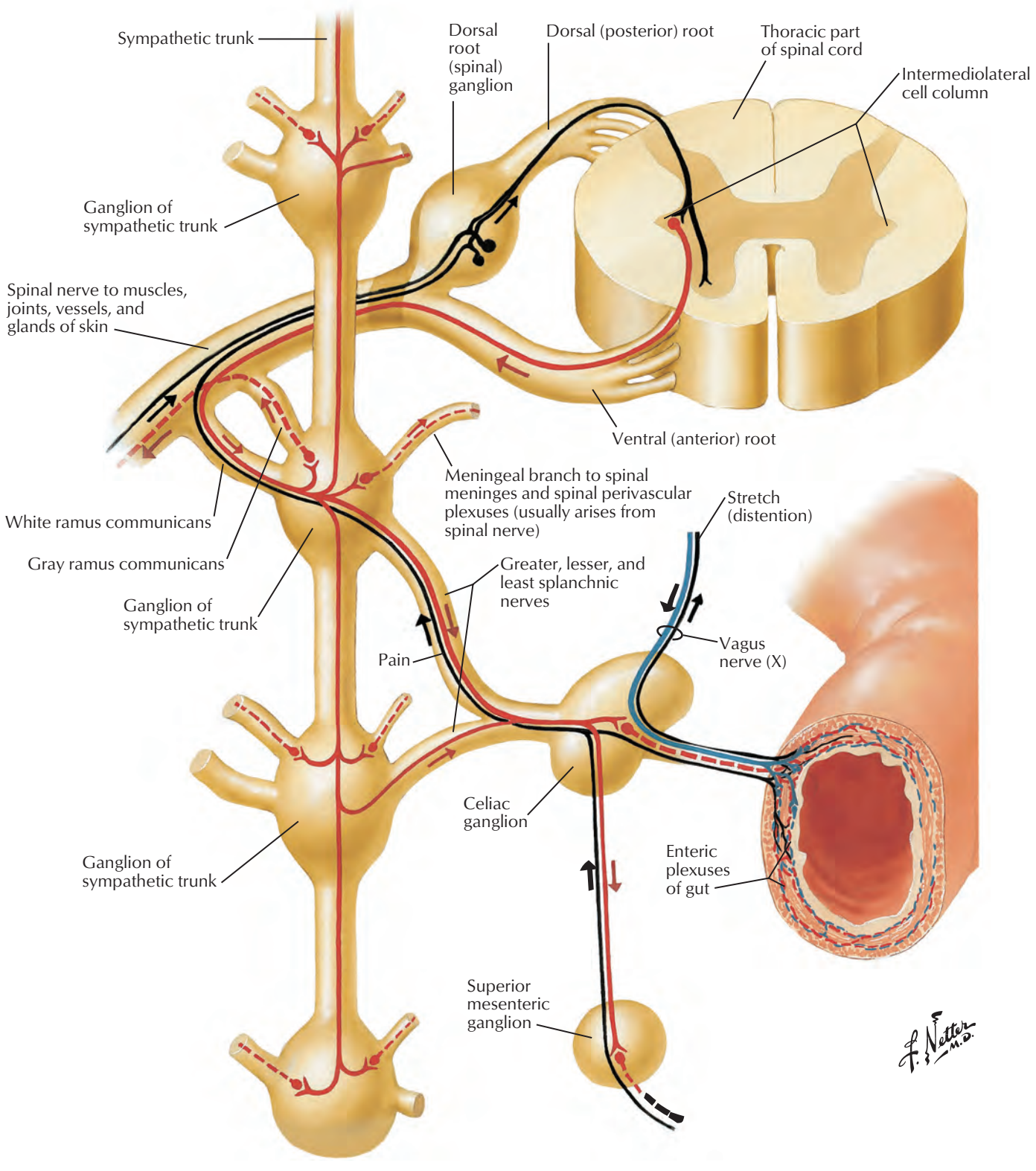
Autonomic Innervation of Small and Large Intestines: Schema

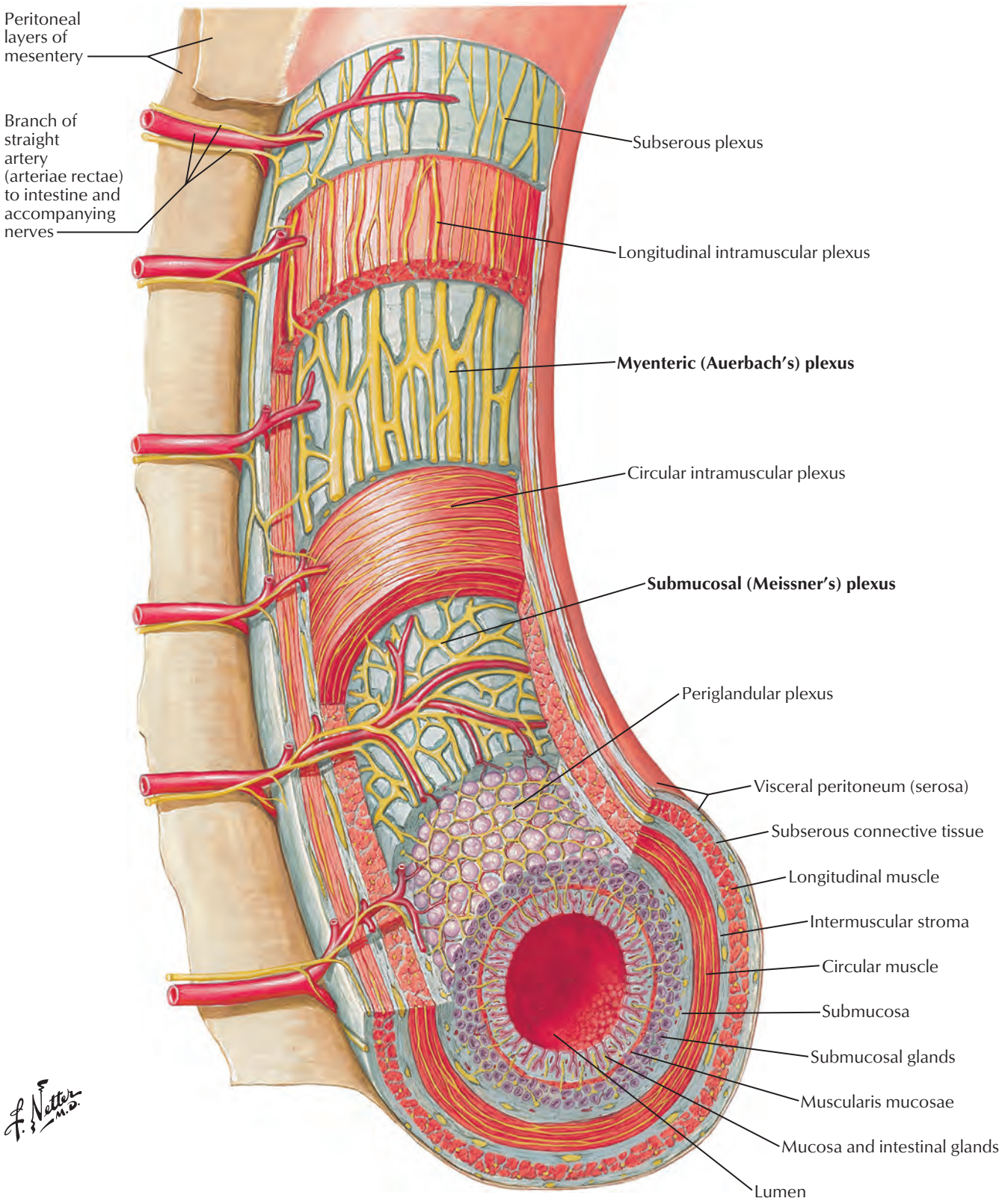
See also **Plates 163, 164**



Chief segmental sources of sympathetic fibers innervating different regions of intestinal tract are indicated. Numerous afferent fibers are carried centripetally through approximately the same sympathetic splanchnic nerves that transmit preganglionic fibers.

Autonomic Reflex Pathways: Schema

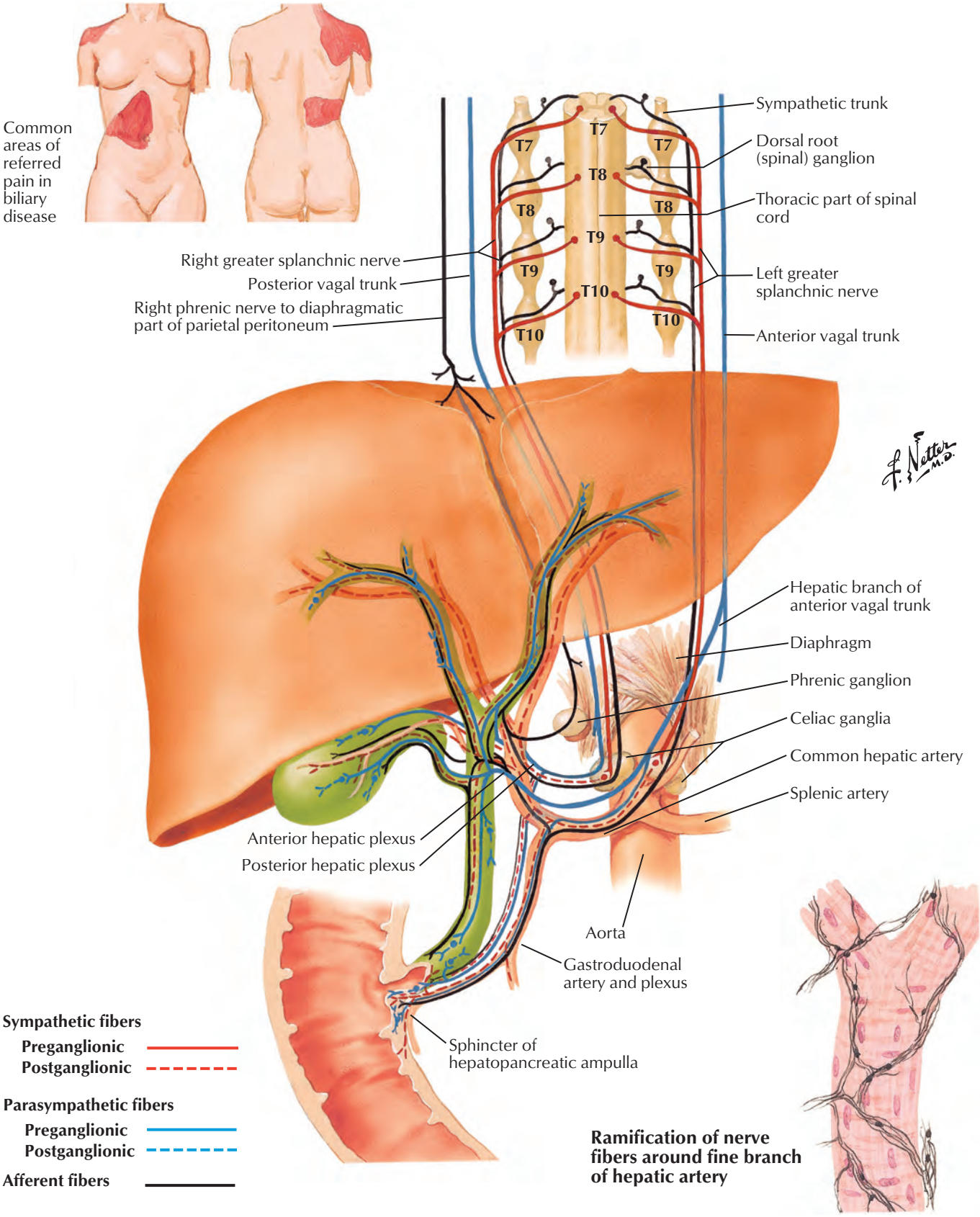




Note: Intestinal wall is shown much thicker than in actuality.

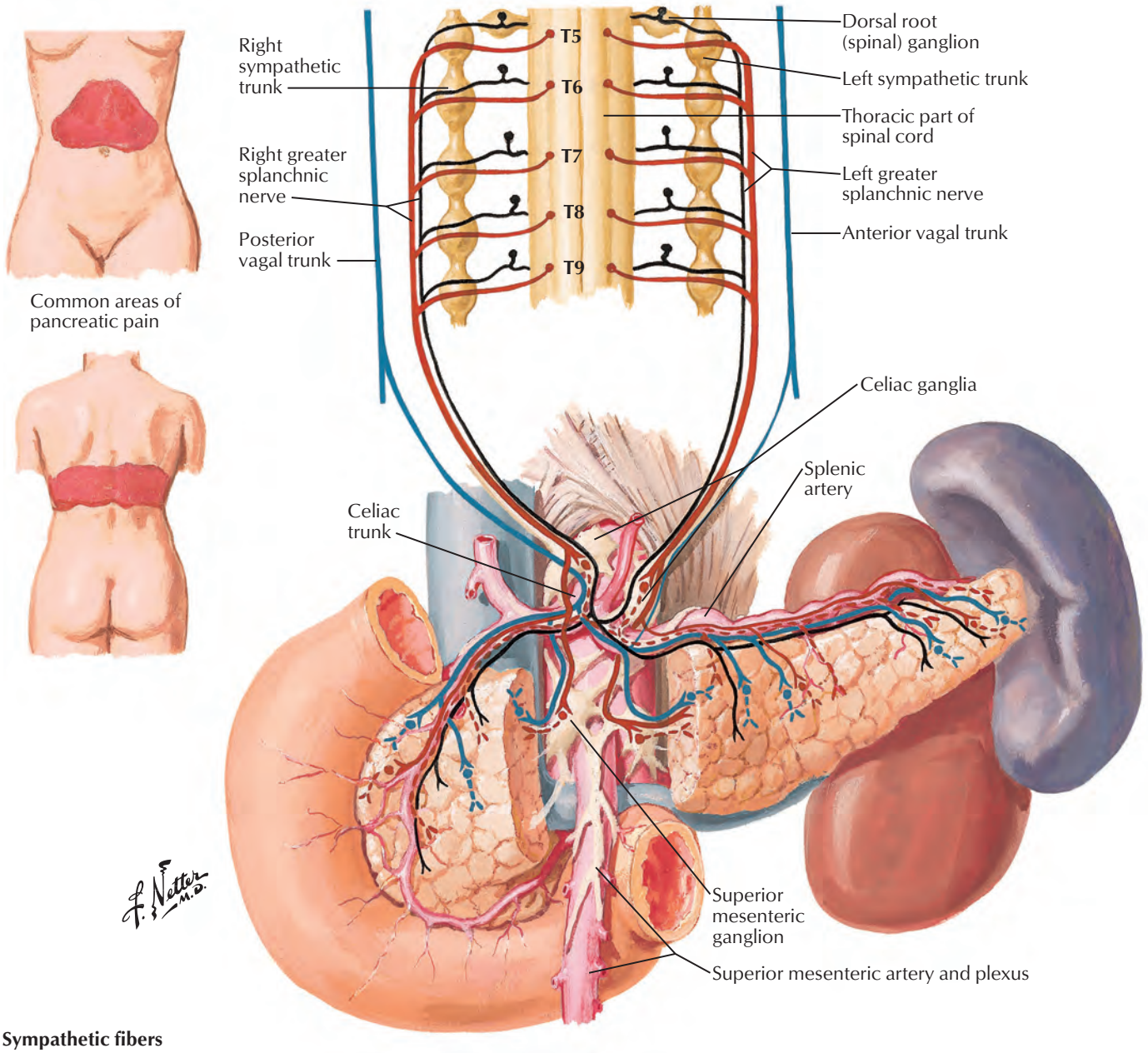
Autonomic Innervation of Liver and Biliary Tract: Schema

See also **Plates 163, 164**



Autonomic Innervation of Pancreas: Schema

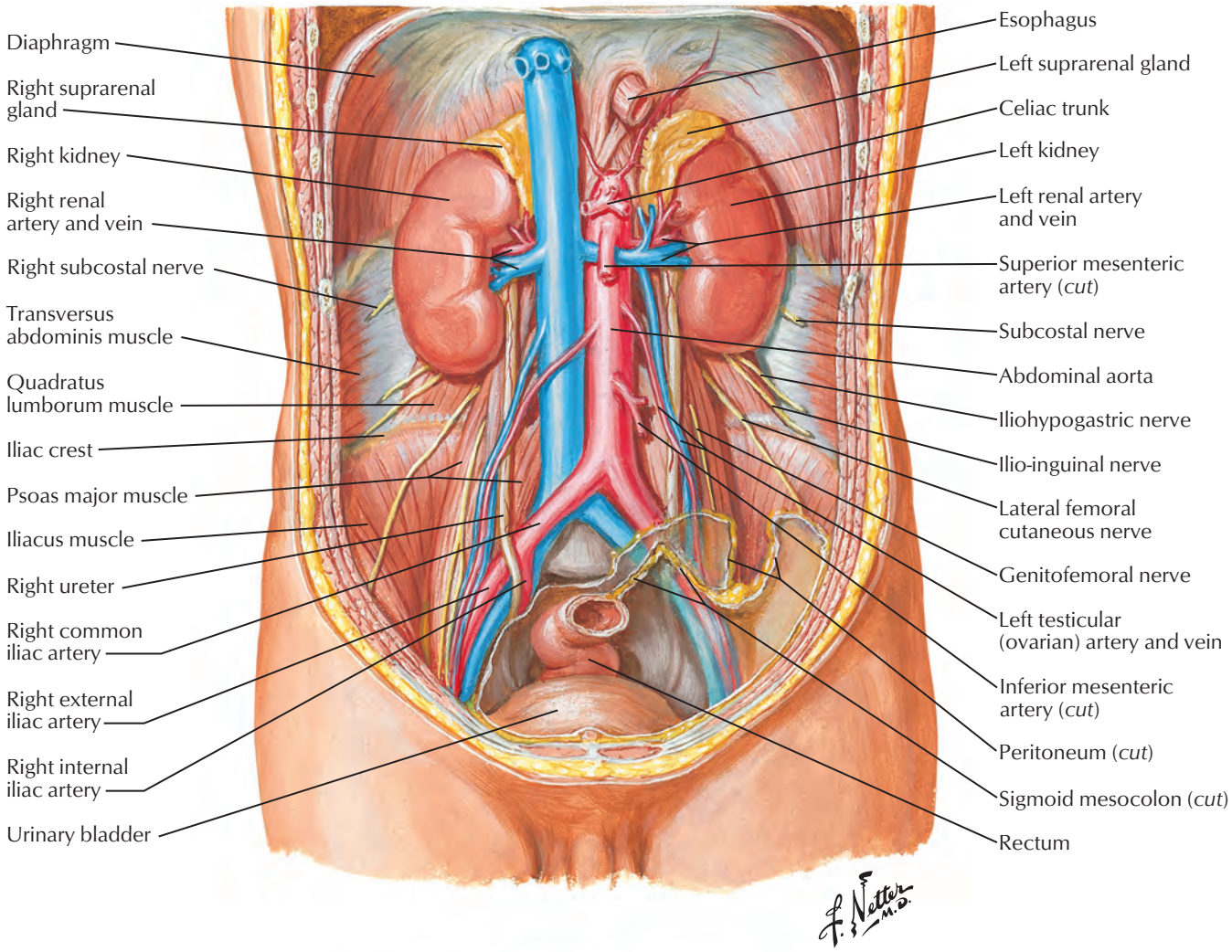
See also **Plates 163, 164**

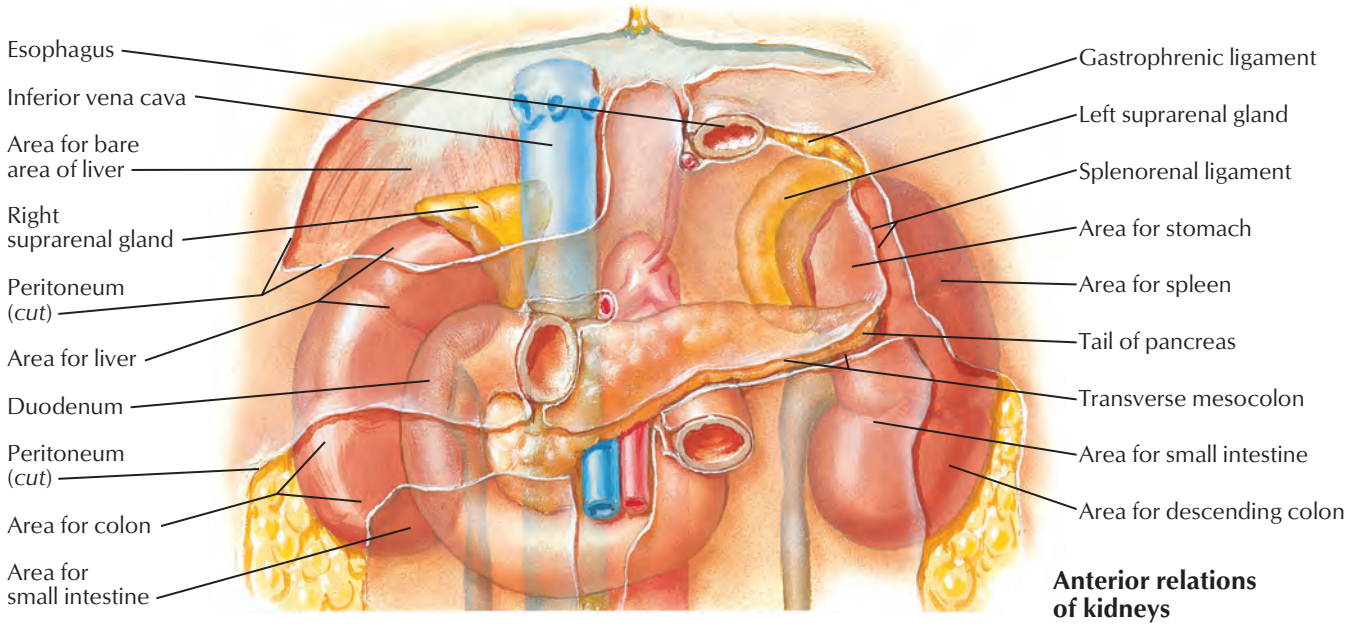


Sympathetic fibers
- **Preganglionic**
- **Postganglionic**

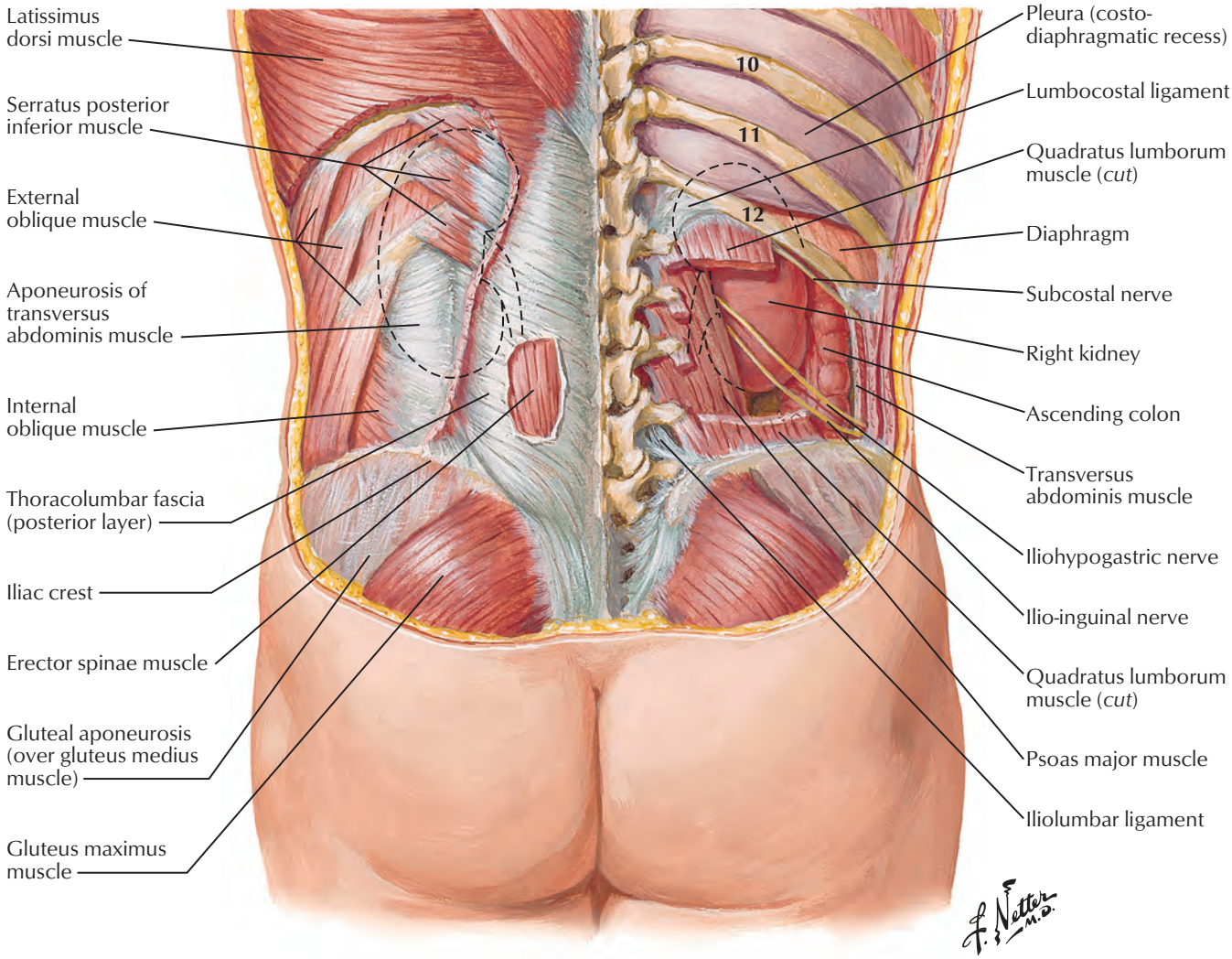
Parasympathetic fibers
- **Preganglionic**
- **Postganglionic**

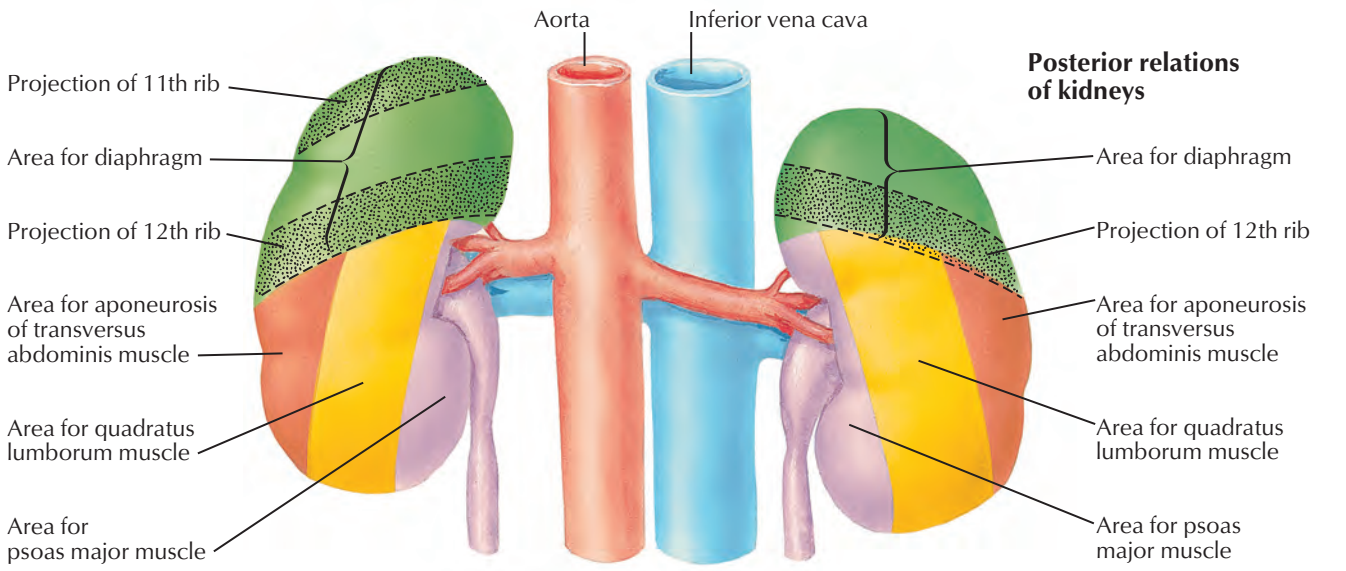
Afferent fibers

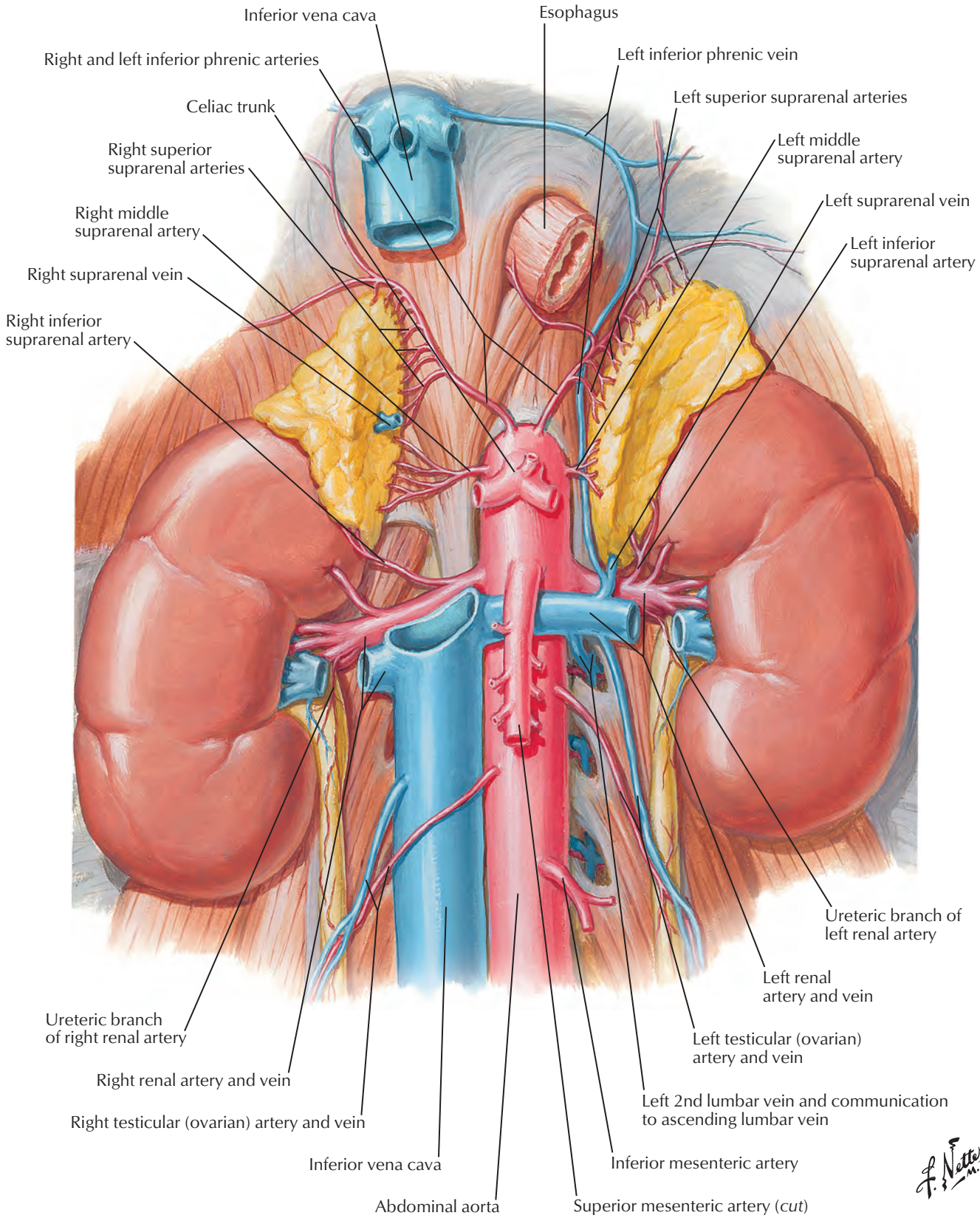


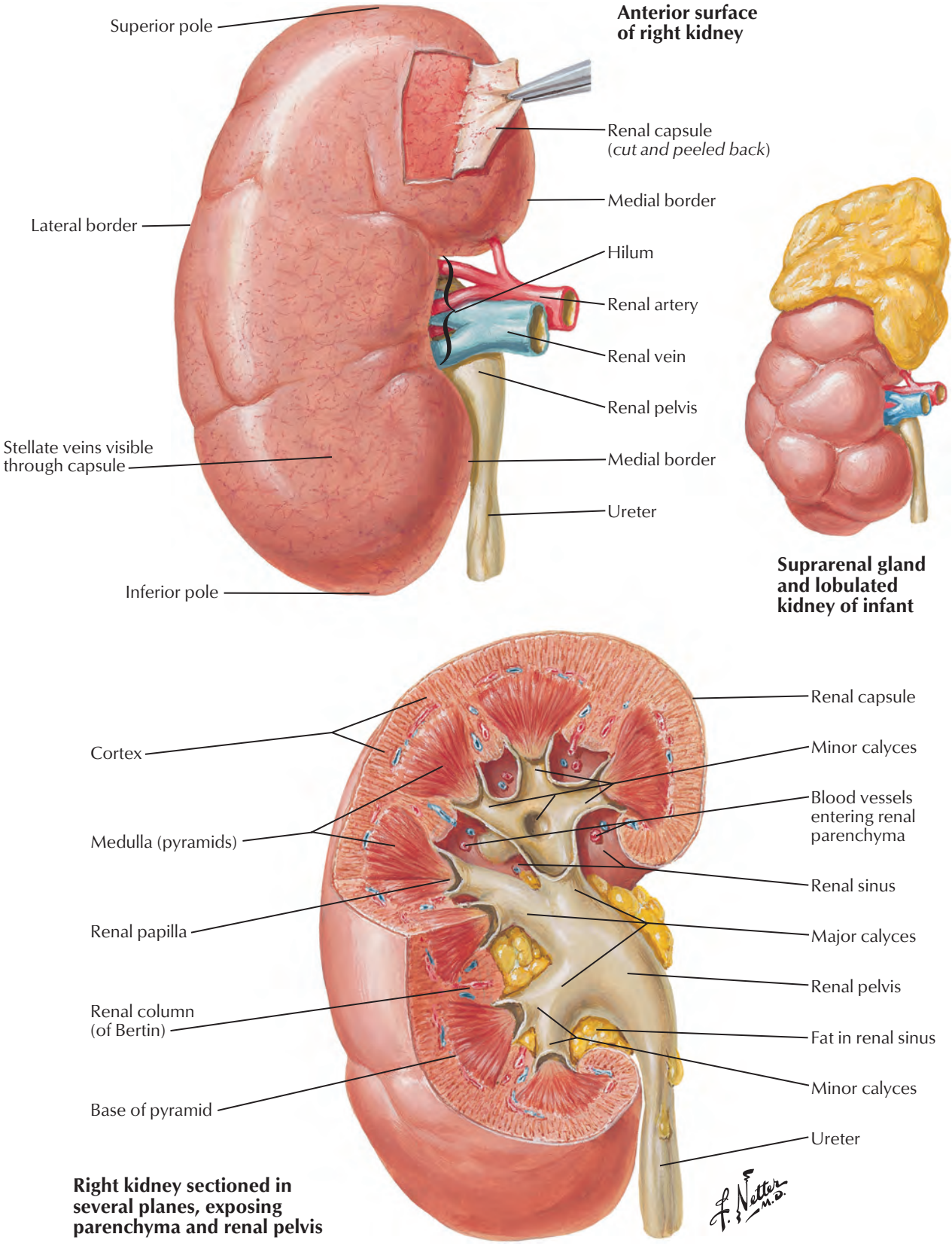


Anterior relations of kidneys

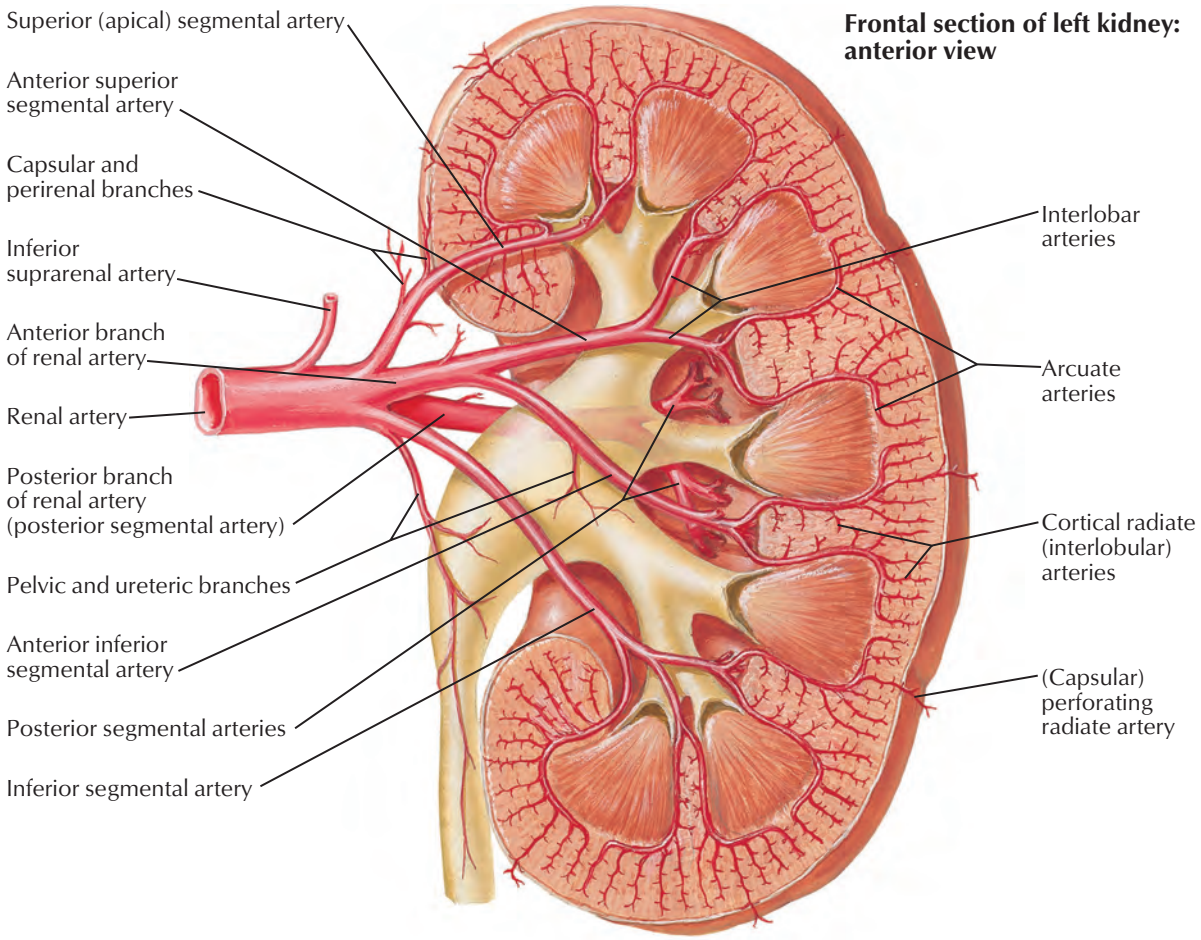

Latissimus dorsi muscle
Serratus posterior inferior muscle
External oblique muscle
Aponeurosis of transversus abdominis muscle
Internal oblique muscle
Thoracolumbar fascia (posterior layer)
Iliac crest
Erector spinae muscle
Gluteal aponeurosis (over gluteus medius muscle)
Gluteus maximus muscle
10
11
12
Pleura (costo-diaphragmatic recess)
Lumbocostal ligament
Quadratus lumborum muscle (cut)
Diaphragm
Subcostal nerve
Right kidney
Ascending colon
Transversus abdominis muscle
Iliohypogastric nerve
Ilio-inguinal nerve
Quadratus lumborum muscle (cut)
Psoas major muscle
Iliolumbar ligament
F. Netter M.D.

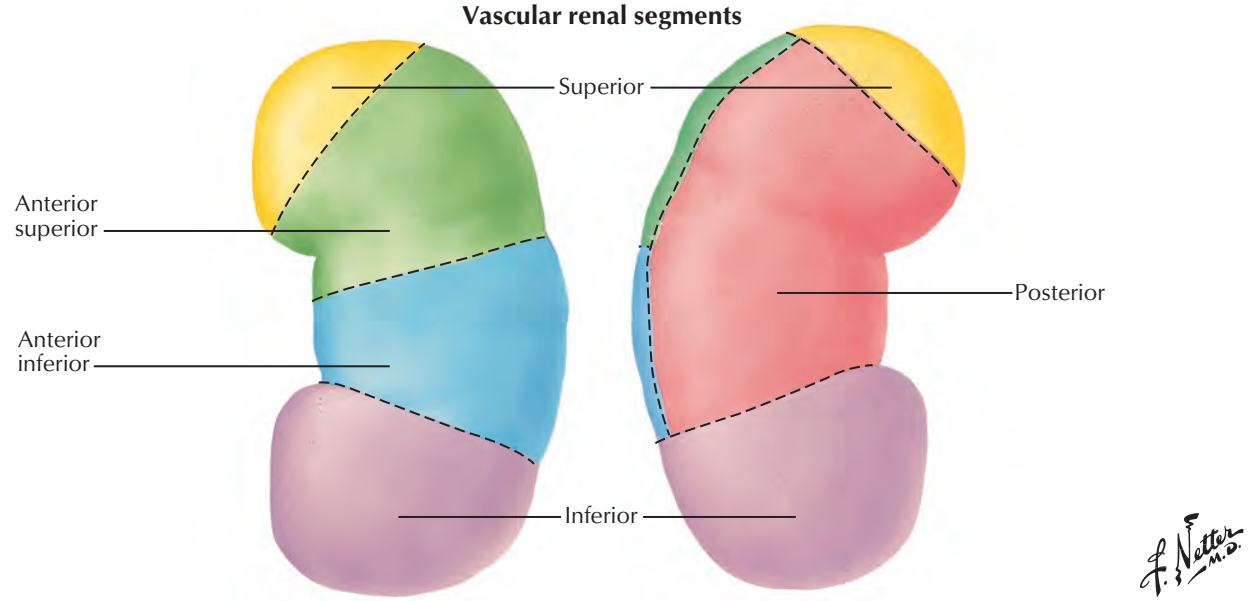

Aorta
Inferior vena cava
Posterior relations of kidneys
Projection of 11th rib
Area for diaphragm
Projection of 12th rib
Area for aponeurosis of transversus abdominis muscle
Area for quadratus lumborum muscle
Area for psoas major muscle
Area for diaphragm
Projection of 12th rib
Area for aponeurosis of transversus abdominis muscle
Area for quadratus lumborum muscle
Area for psoas major muscle


Inferior vena cava
Esophagus
Right and left inferior phrenic arteries
Left inferior phrenic vein
Celiac trunk
Left superior suprarenal arteries
Right superior suprarenal arteries
Left middle suprarenal artery
Left suprarenal vein
Right middle suprarenal artery
Left inferior suprarenal artery
Right suprarenal vein
Right inferior suprarenal artery
Ureteric branch of left renal artery
Left renal artery and vein
Left testicular (ovarian) artery and vein
Ureteric branch of right renal artery
Right renal artery and vein
Left 2nd lumbar vein and communication to ascending lumbar vein
Right testicular (ovarian) artery and vein
Inferior vena cava
Inferior mesenteric artery
Abdominal aorta
Superior mesenteric artery (cut)



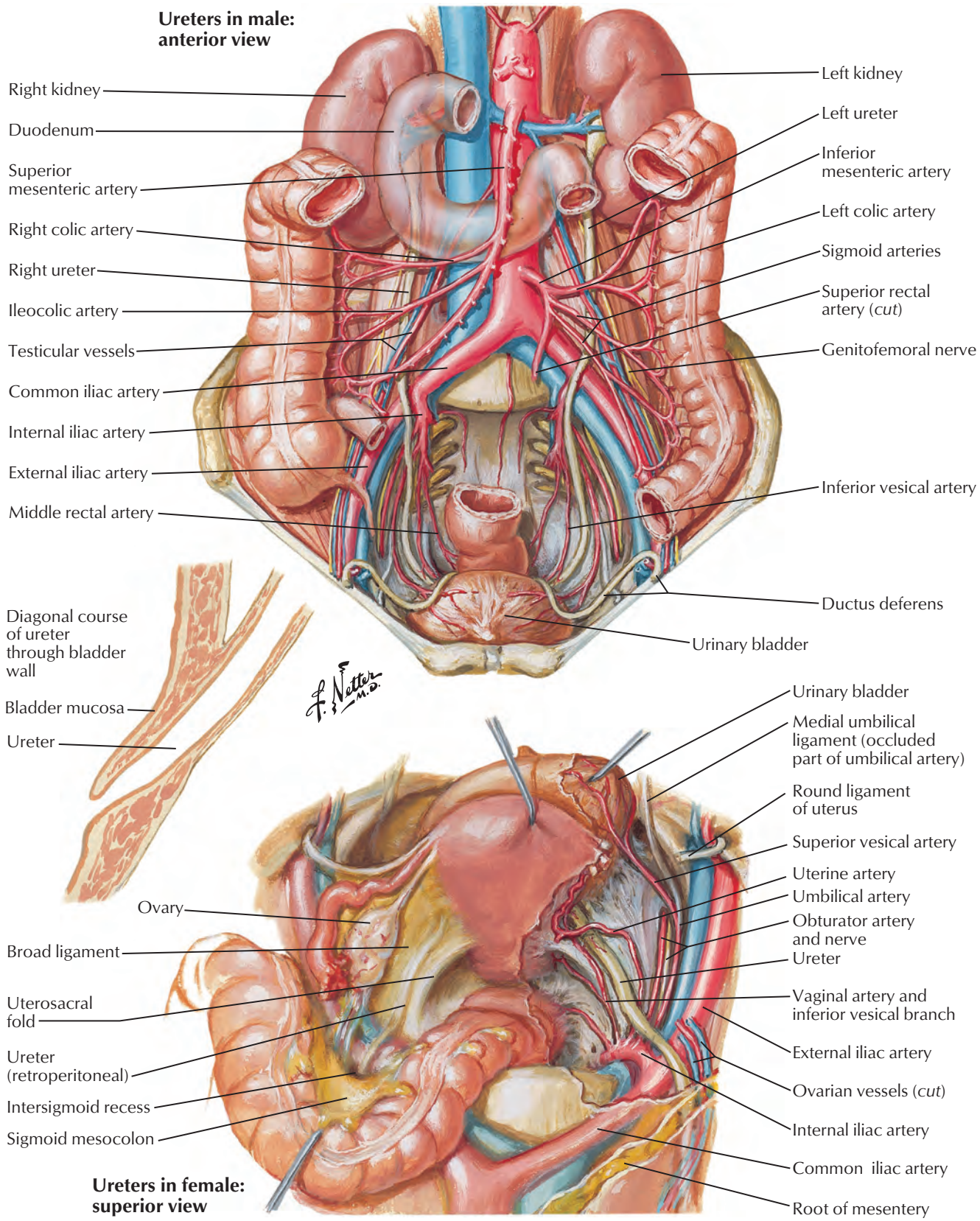
Right kidney sectioned in several planes, exposing parenchyma and renal pelvis

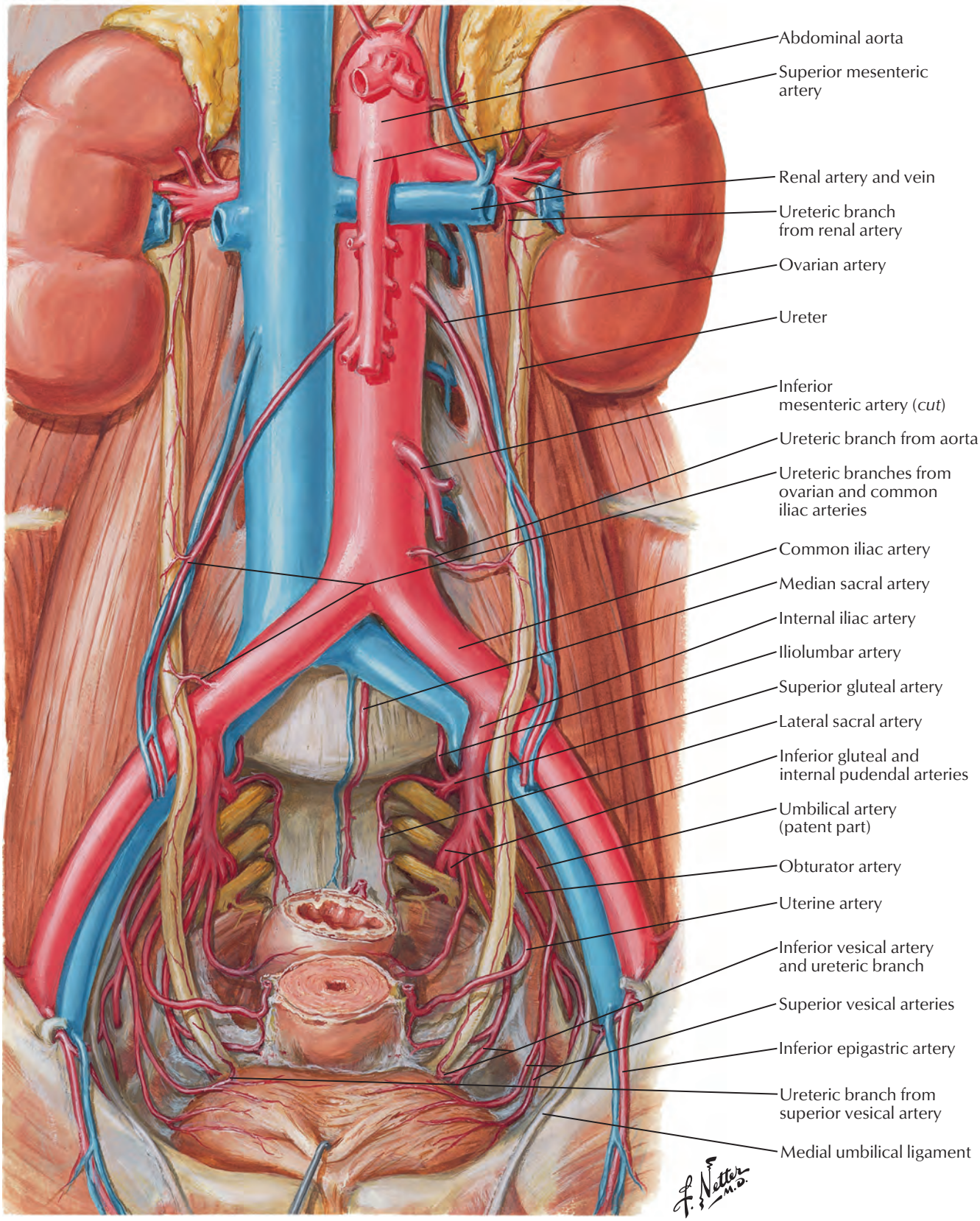


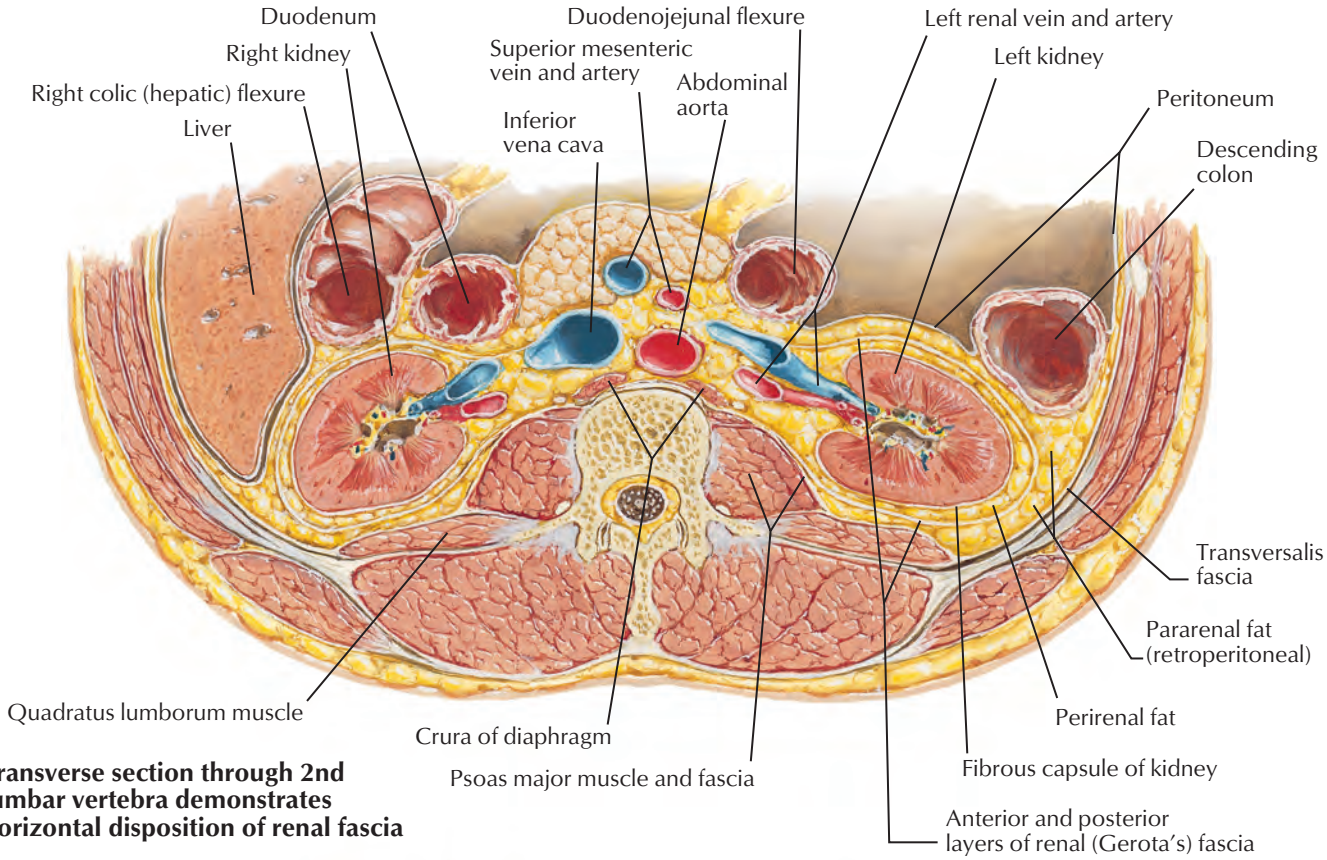


Anterior surface of left kidney

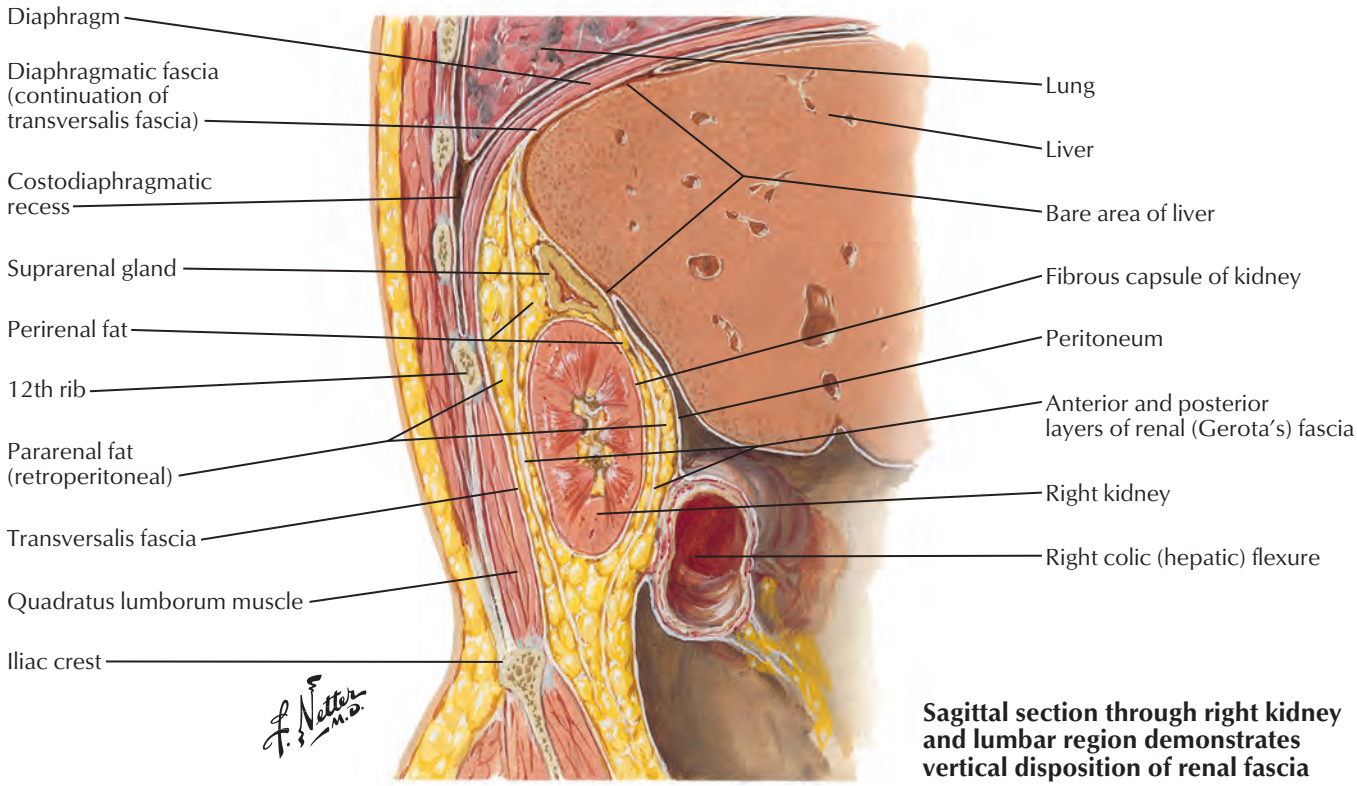
Posterior surface of left kidney


Ureters in male: anterior view
Right kidney
Duodenum
Superior mesenteric artery
Right colic artery
Right ureter
Ileocolic artery
Testicular vessels
Common iliac artery
Internal iliac artery
External iliac artery
Middle rectal artery
Left kidney
Left ureter
Inferior mesenteric artery
Left colic artery
Sigmoid arteries
Superior rectal artery (cut)
Genitofemoral nerve
Inferior vesical artery
Ductus deferens
Urinary bladder
Diagonal course of ureter through bladder wall
Bladder mucosa
Ureter
F. Netter M.D.
Urinary bladder
Medial umbilical ligament (occluded part of umbilical artery)
Round ligament of uterus
Superior vesical artery
Uterine artery
Umbilical artery
Obturator artery and nerve
Ureter
Vaginal artery and inferior vesical branch
External iliac artery
Ovarian vessels (cut)
Internal iliac artery
Common iliac artery
Root of mesentery
Ovary
Broad ligament
Uterosacral fold
Ureter (retroperitoneal)
Intersigmoid recess
Sigmoid mesocolon
Ureters in female: superior view


Abdominal aorta
Superior mesenteric artery
Renal artery and vein
Ureteric branch from renal artery
Ovarian artery
Ureter
Inferior mesenteric artery (*cut*)
Ureteric branch from aorta
Ureteric branches from ovarian and common iliac arteries
Common iliac artery
Median sacral artery
Internal iliac artery
Iliolumbar artery
Superior gluteal artery
Lateral sacral artery
Inferior gluteal and internal pudendal arteries
Umbilical artery (patent part)
Obturator artery
Uterine artery
Inferior vesical artery and ureteric branch
Superior vesical arteries
Inferior epigastric artery
Ureteric branch from superior vesical artery
Medial umbilical ligament



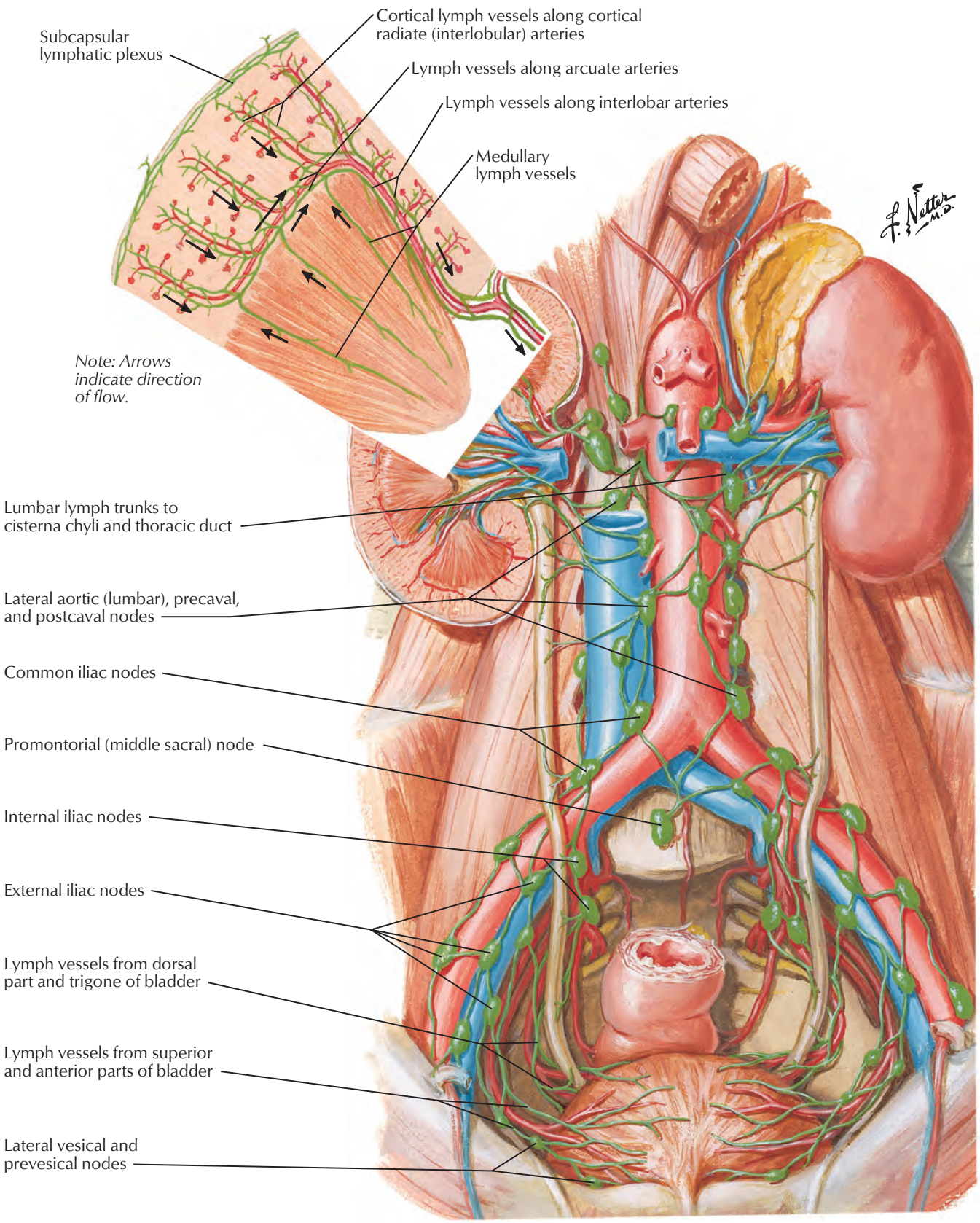
Transverse section through 2nd lumbar vertebra demonstrates horizontal disposition of renal fascia

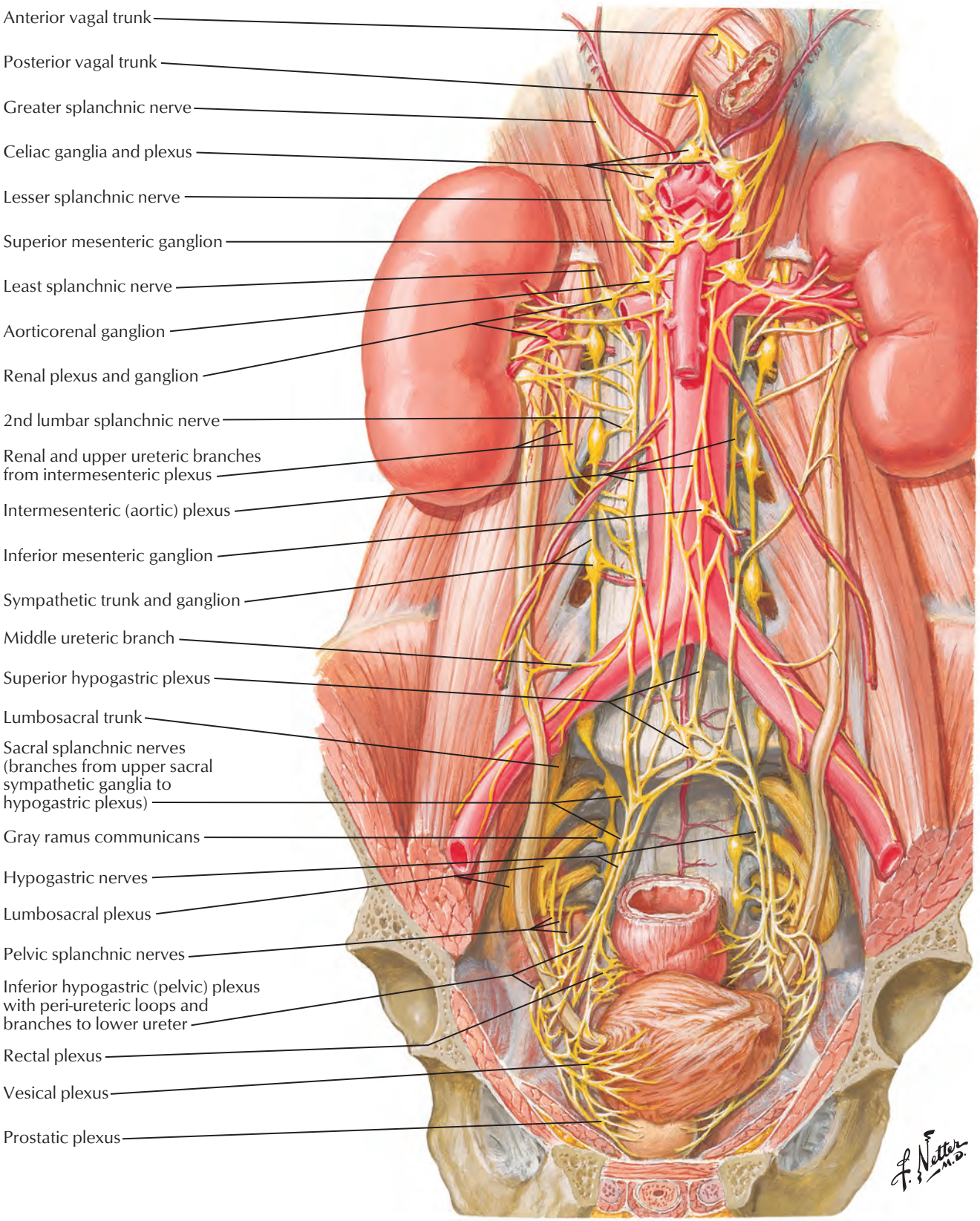


Sagittal section through right kidney and lumbar region demonstrates vertical disposition of renal fascia

Lymph Vessels and Nodes of Kidneys and Urinary Bladder

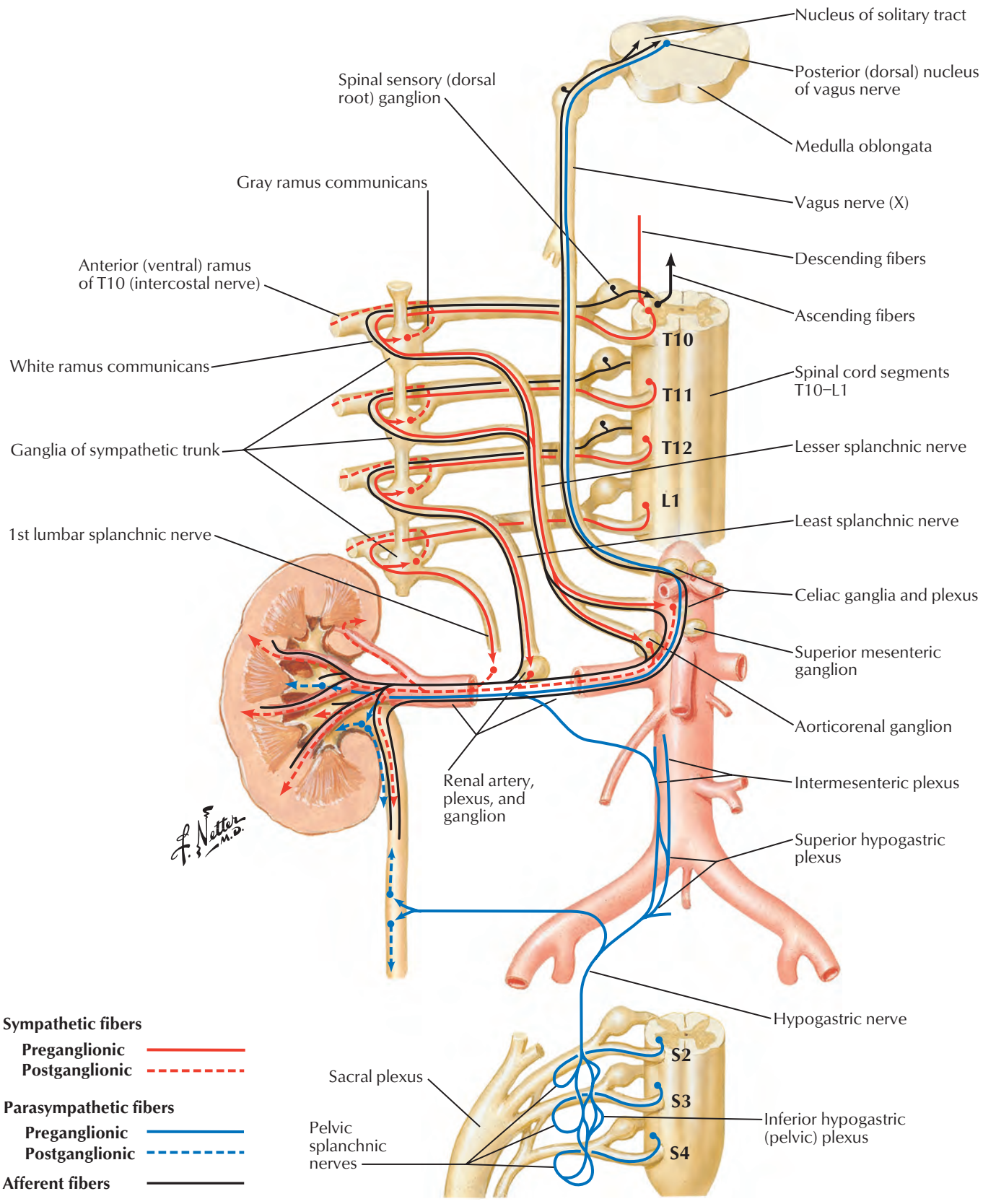
See also **Plates 384, 386**




Anterior vagal trunk
Posterior vagal trunk
Greater splanchnic nerve
Celiac ganglia and plexus
Lesser splanchnic nerve
Superior mesenteric ganglion
Least splanchnic nerve
Aorticorenal ganglion
Renal plexus and ganglion
2nd lumbar splanchnic nerve
Renal and upper ureteric branches from intermesenteric plexus
Intermesenteric (aortic) plexus
Inferior mesenteric ganglion
Sympathetic trunk and ganglion
Middle ureteric branch
Superior hypogastric plexus
Lumbosacral trunk
Sacral splanchnic nerves (branches from upper sacral sympathetic ganglia to hypogastric plexus)
Gray ramus communicans
Hypogastric nerves
Lumbosacral plexus
Pelvic splanchnic nerves
Inferior hypogastric (pelvic) plexus with peri-ureteric loops and branches to lower ureter
Rectal plexus
Vesical plexus
Prostatic plexus
F. Netter M.D.

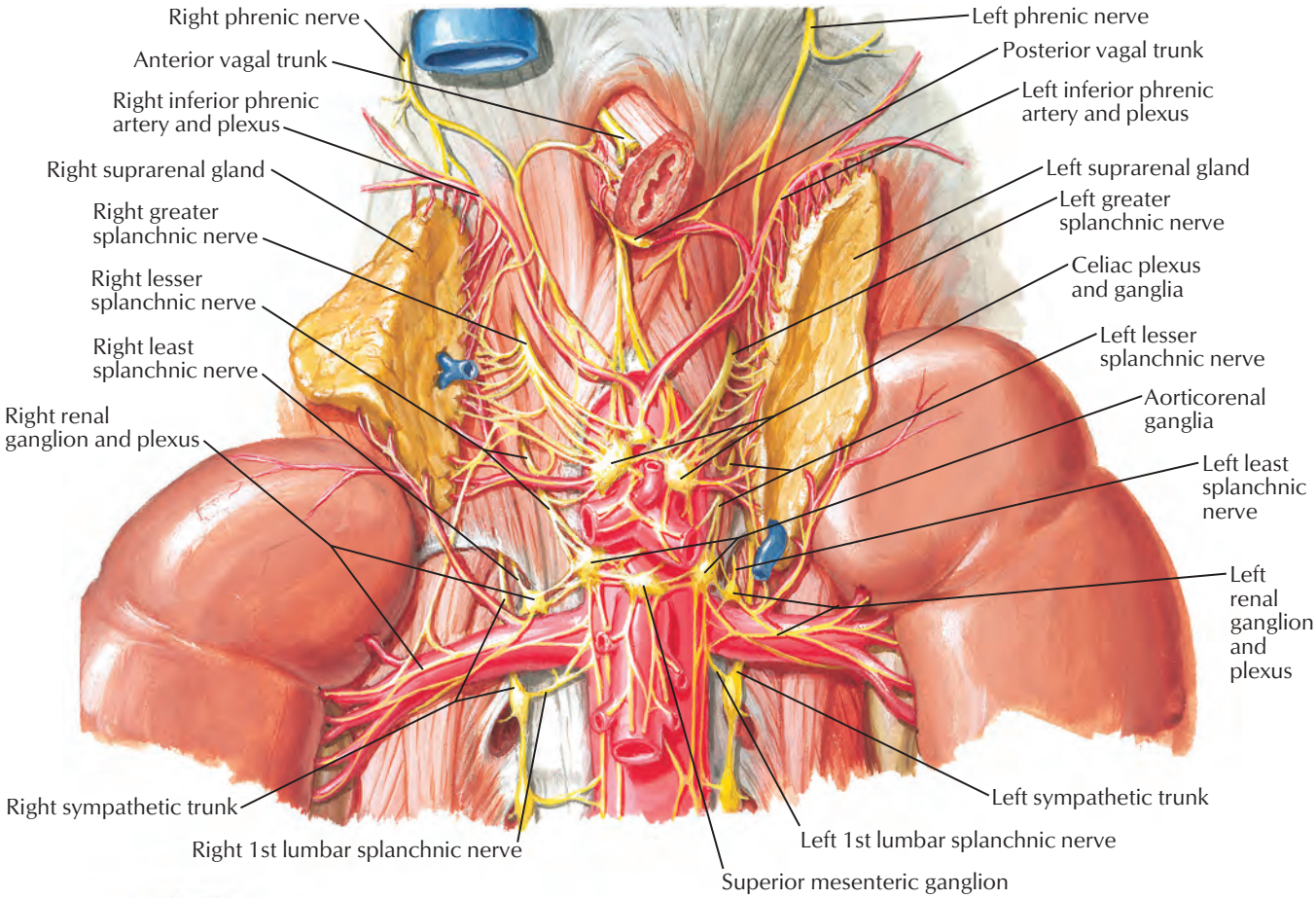
Autonomic Innervation of Kidneys and Upper Ureters: Schema

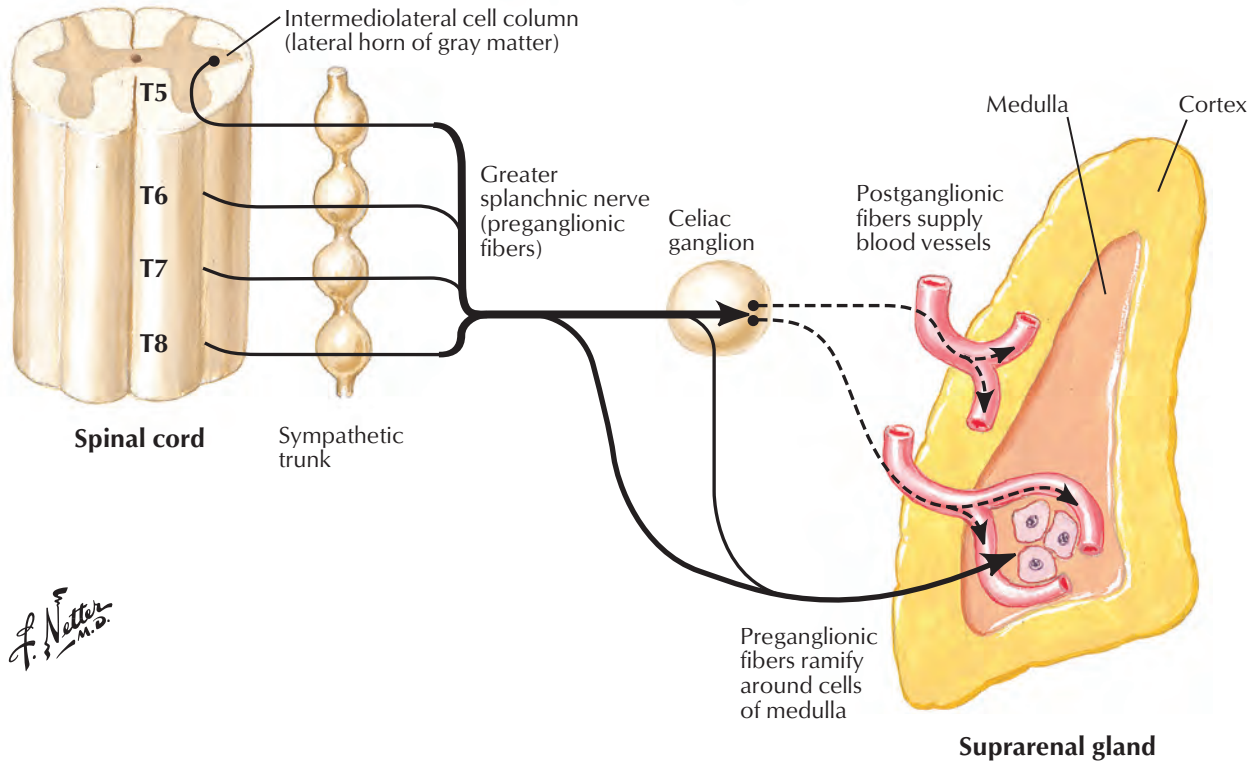
See also **Plates 163, 164, 395**

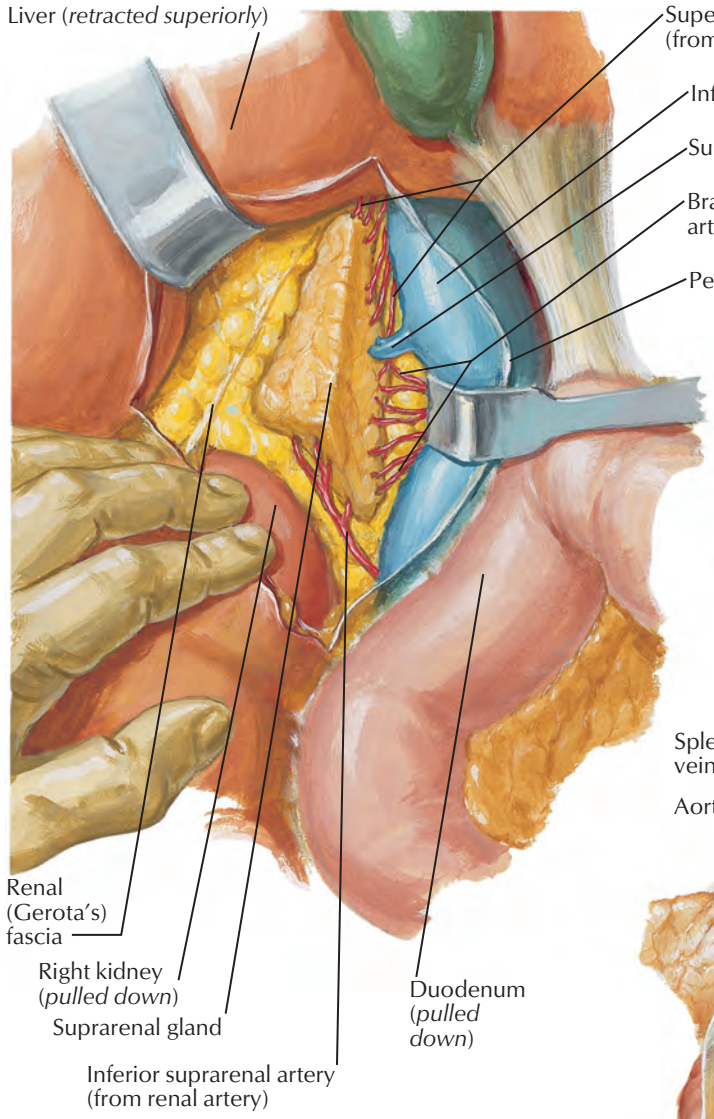


Autonomic Nerves of Suprarenal Glands: Dissection and Schema

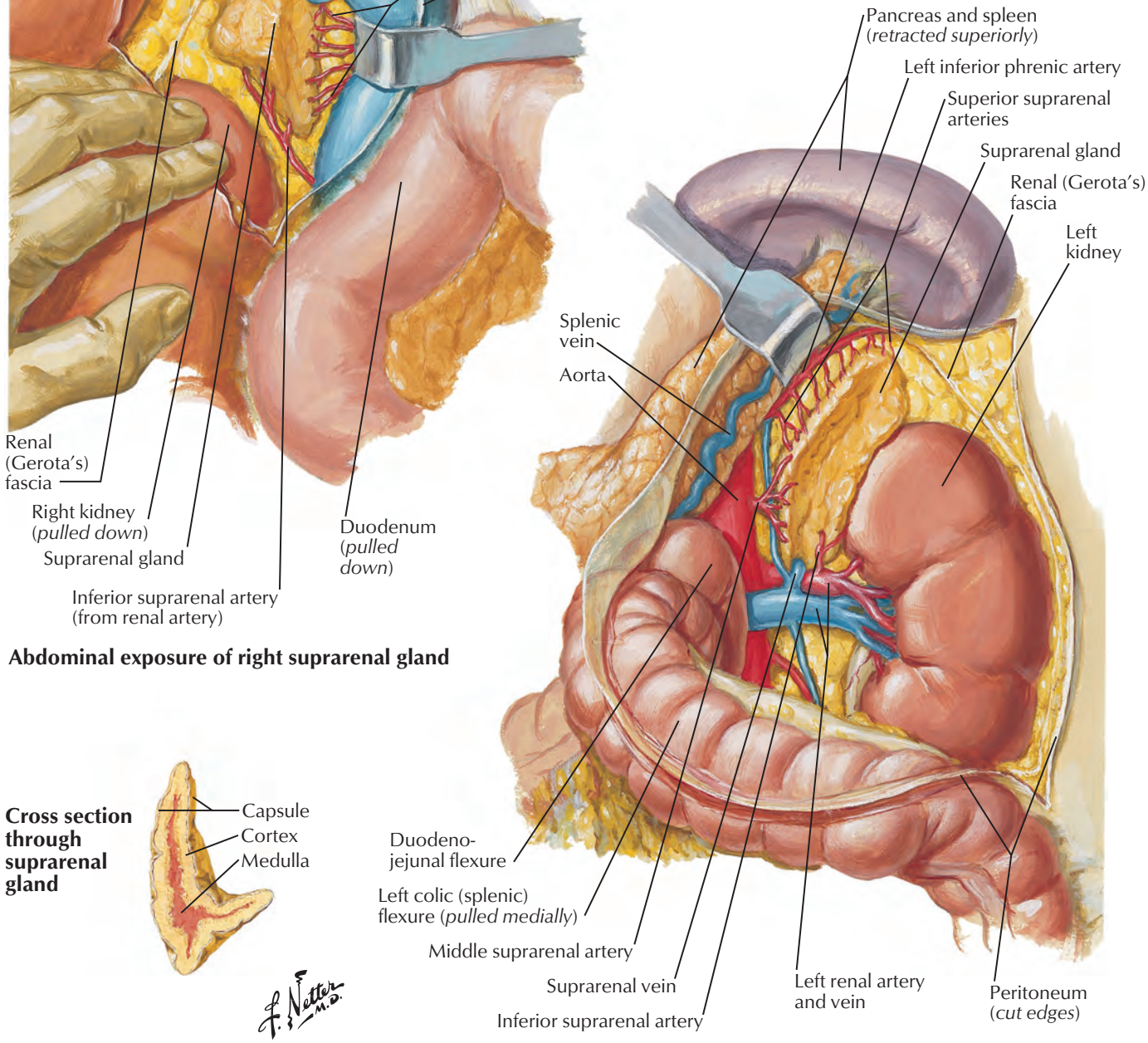
See also **Plates 163, 164**





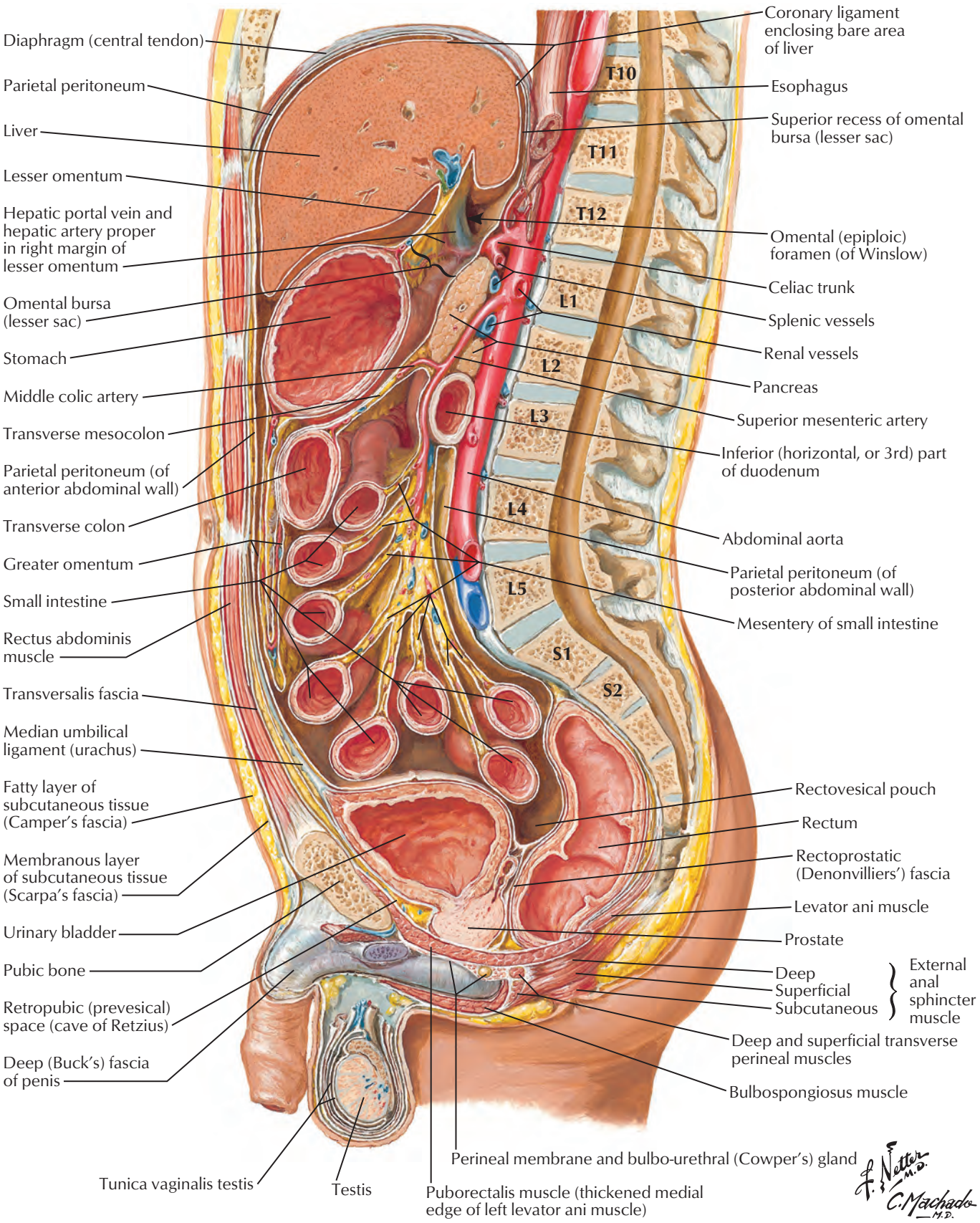


Abdominal exposure of right suprarenal gland

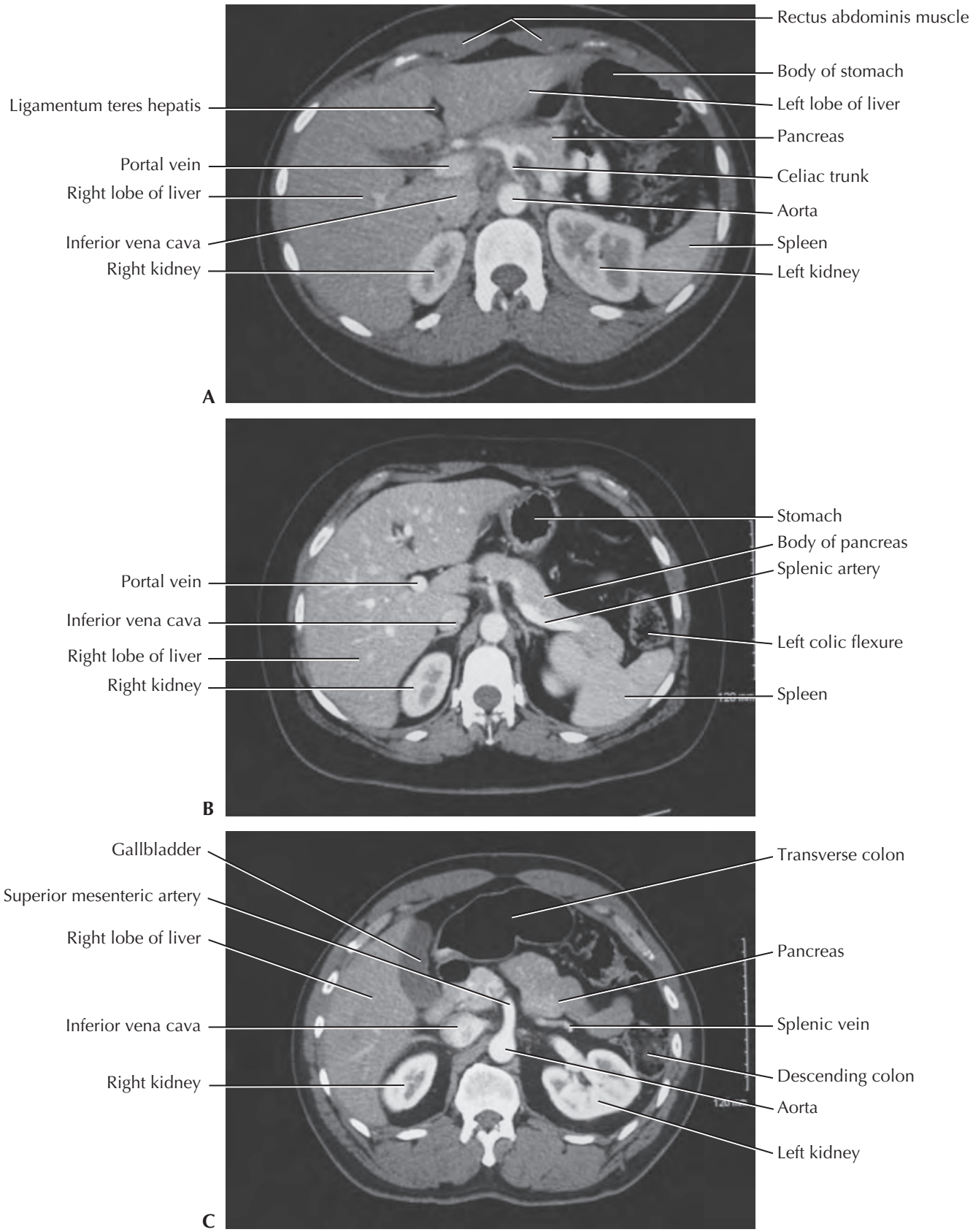


Abdominal exposure of left suprarenal gland

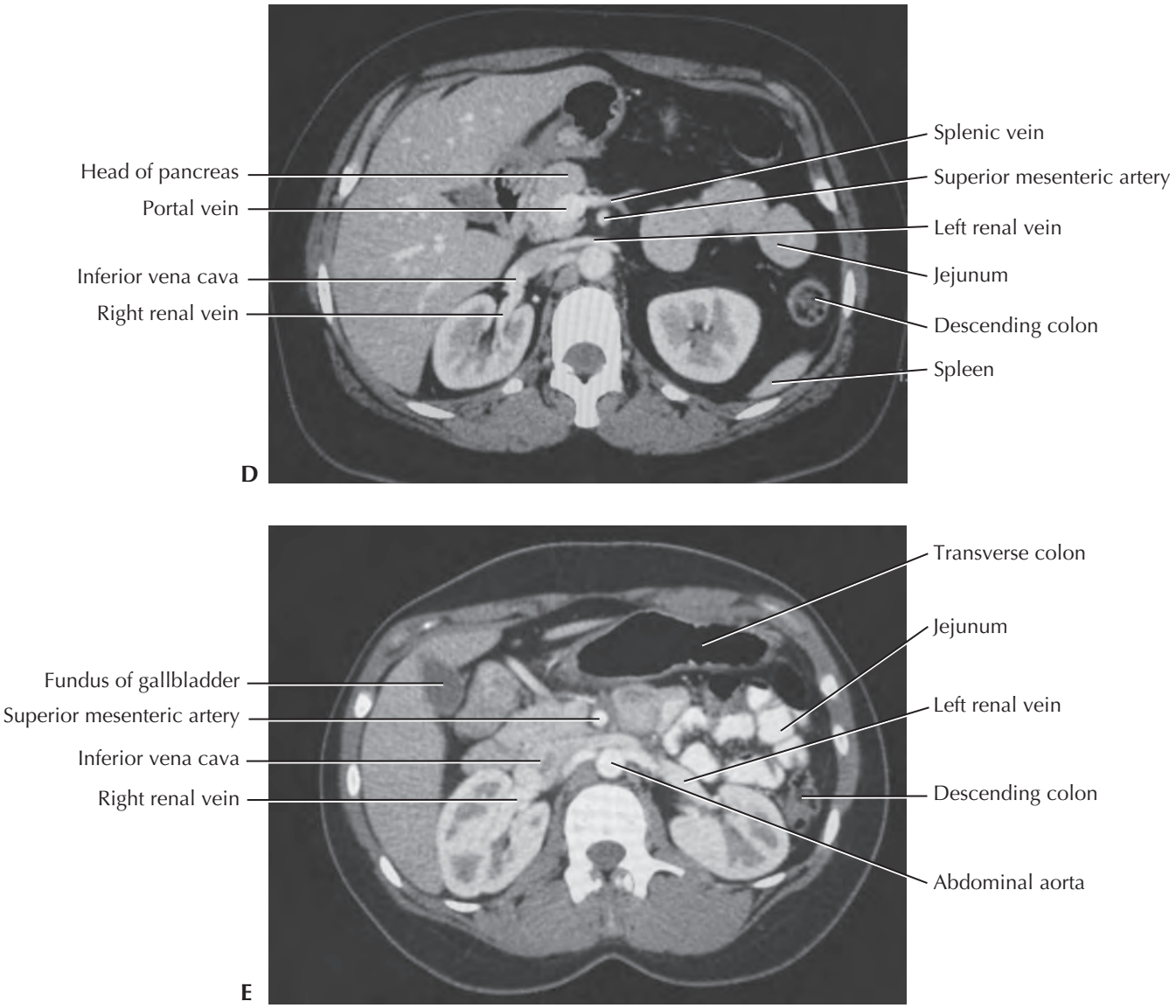
Cross section through suprarenal gland


Diaphragm (central tendon)
Parietal peritoneum
Liver
Lesser omentum
Hepatic portal vein and hepatic artery proper in right margin of lesser omentum
Omental bursa (lesser sac)
Stomach
Middle colic artery
Transverse mesocolon
Parietal peritoneum (of anterior abdominal wall)
Transverse colon
Greater omentum
Small intestine
Rectus abdominis muscle
Transversalis fascia
Median umbilical ligament (urachus)
Fatty layer of subcutaneous tissue (Camper's fascia)
Membranous layer of subcutaneous tissue (Scarpa's fascia)
Urinary bladder
Pubic bone
Retropubic (prevesical) space (cave of Retzius)
Deep (Buck's) fascia of penis
Tunica vaginalis testis
Testis
Puborectalis muscle (thickened medial edge of left levator ani muscle)
Perineal membrane and bulbo-urethral (Cowper's) gland
Bulbospongiosus muscle
Deep and superficial transverse perineal muscles
Deep
Superficial
Subcutaneous
External anal sphincter muscle
Levator ani muscle
Rectoprostatic (Denonvilliers') fascia
Rectum
Rectovesical pouch
Prostate
Mesentery of small intestine
Parietal peritoneum (of posterior abdominal wall)
Abdominal aorta
Inferior (horizontal, or 3rd) part of duodenum
Superior mesenteric artery
Pancreas
Renal vessels
Splenic vessels
Celiac trunk
Omental (epiploic) foramen (of Winslow)
Superior recess of omental bursa (lesser sac)
Esophagus
Coronary ligament enclosing bare area of liver
T10
T11
T12
L1
L2
L3
L4
L5
S1
S2
F. Netter M.D.
C. Machado M.D.

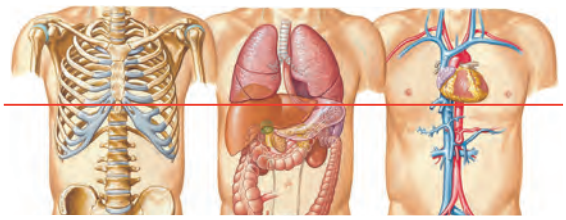
Series of abdominal axial CT images from superior (A) to inferior (C)

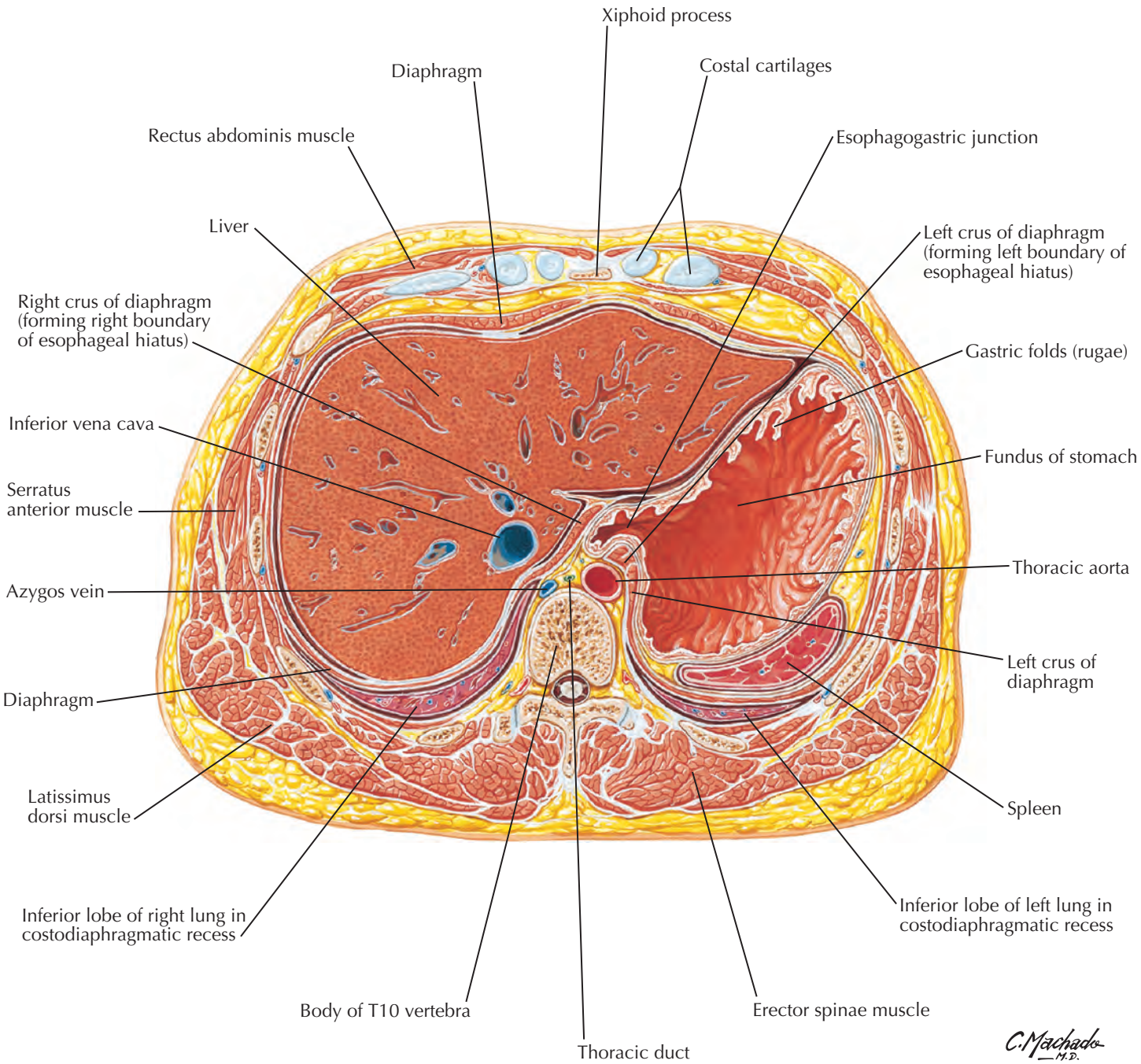


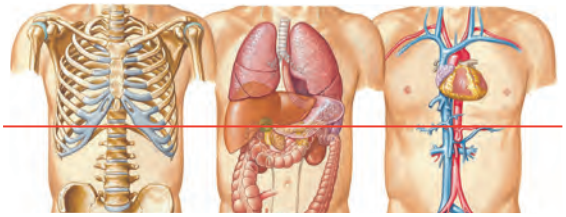
Series of abdominal axial CT images from superior (D) to inferior (E)

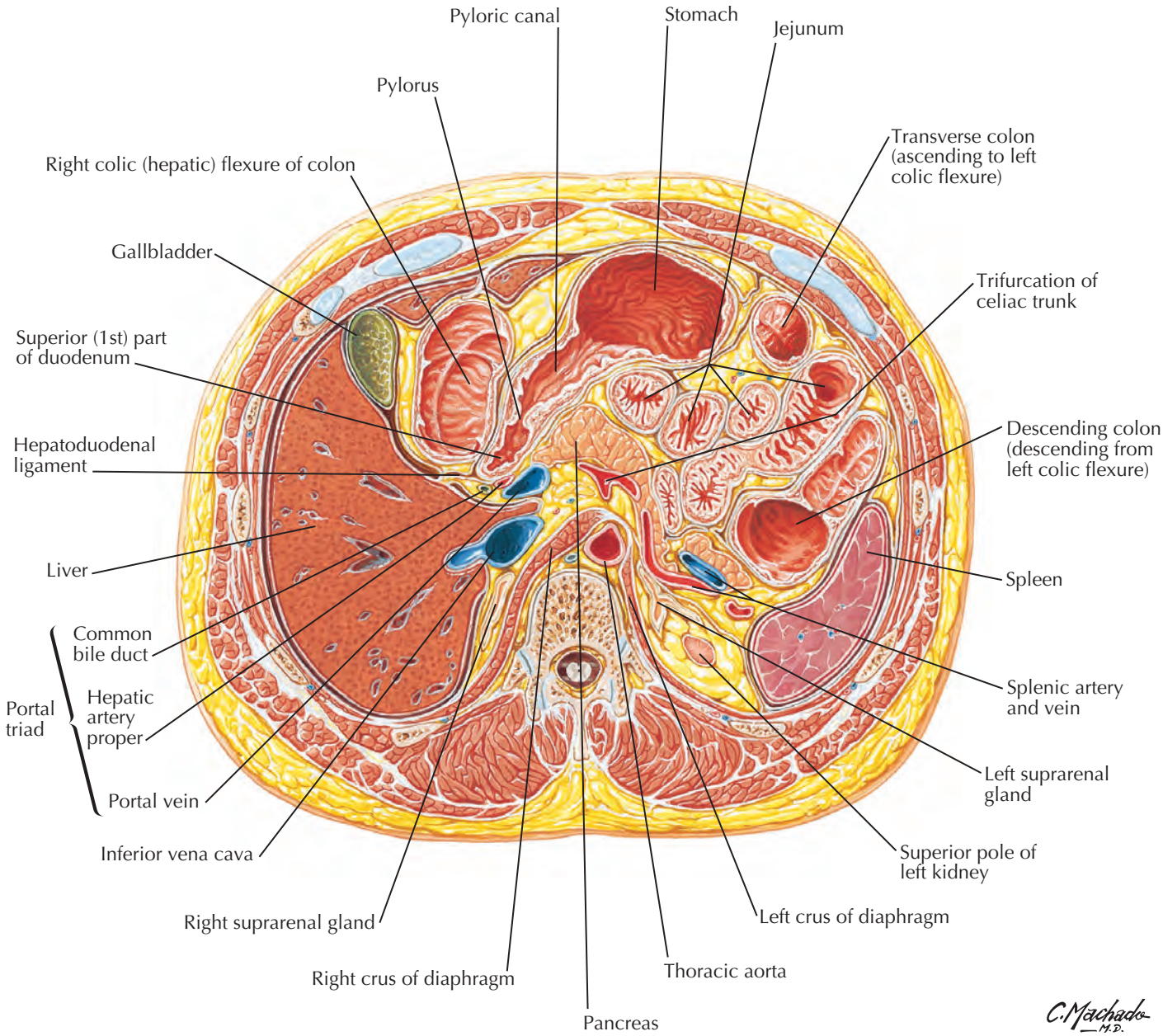


Cross Section at T10, Esophagogastric Junction

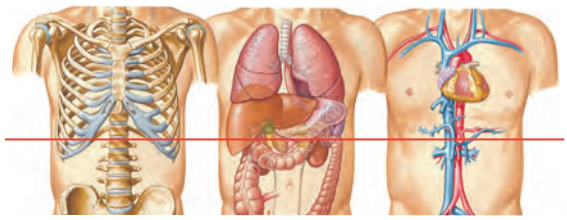


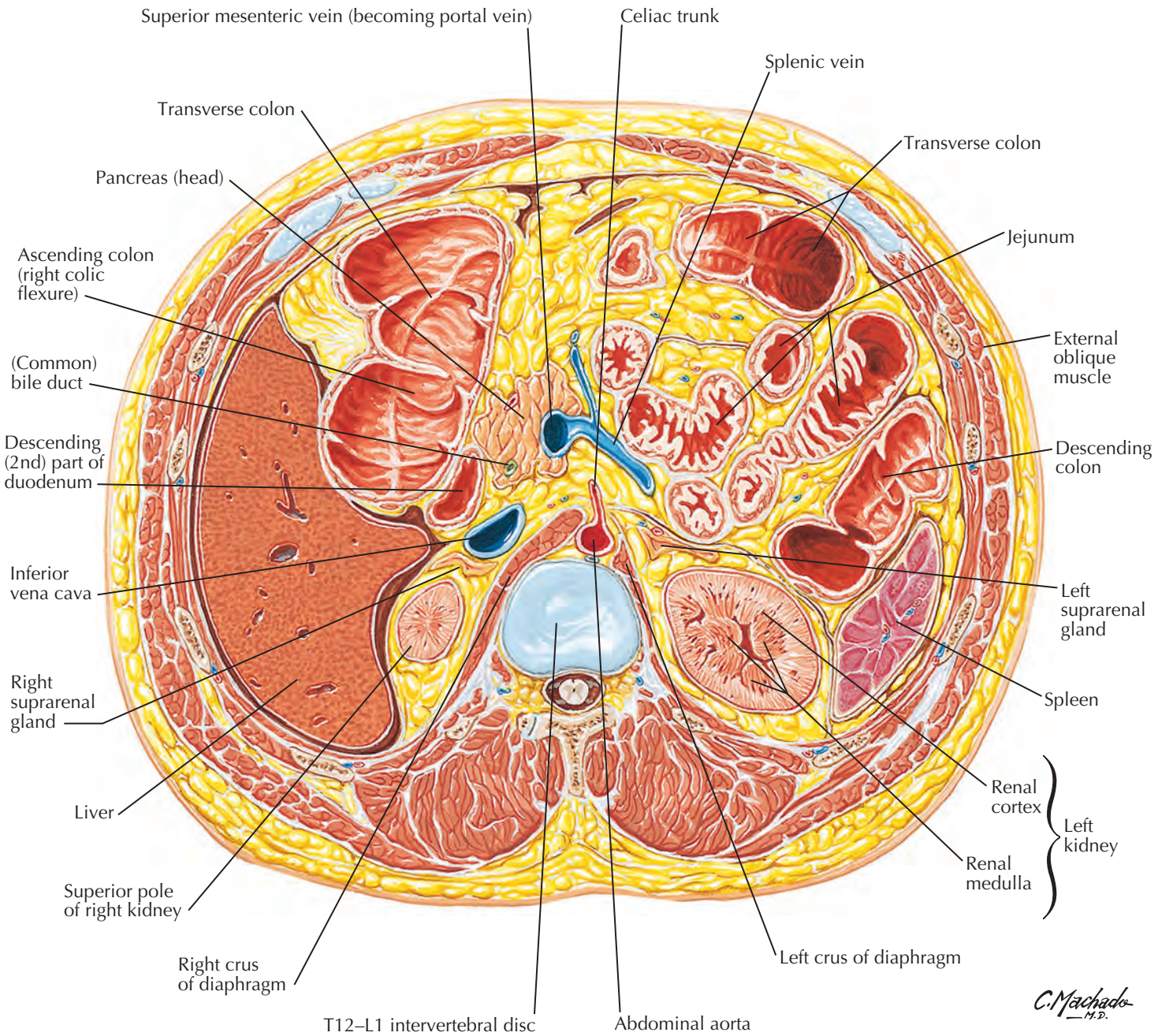


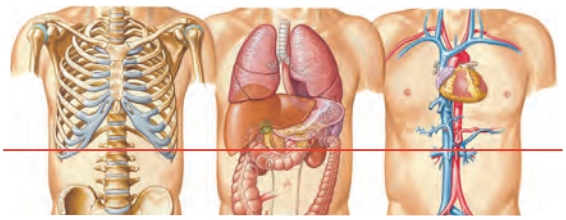


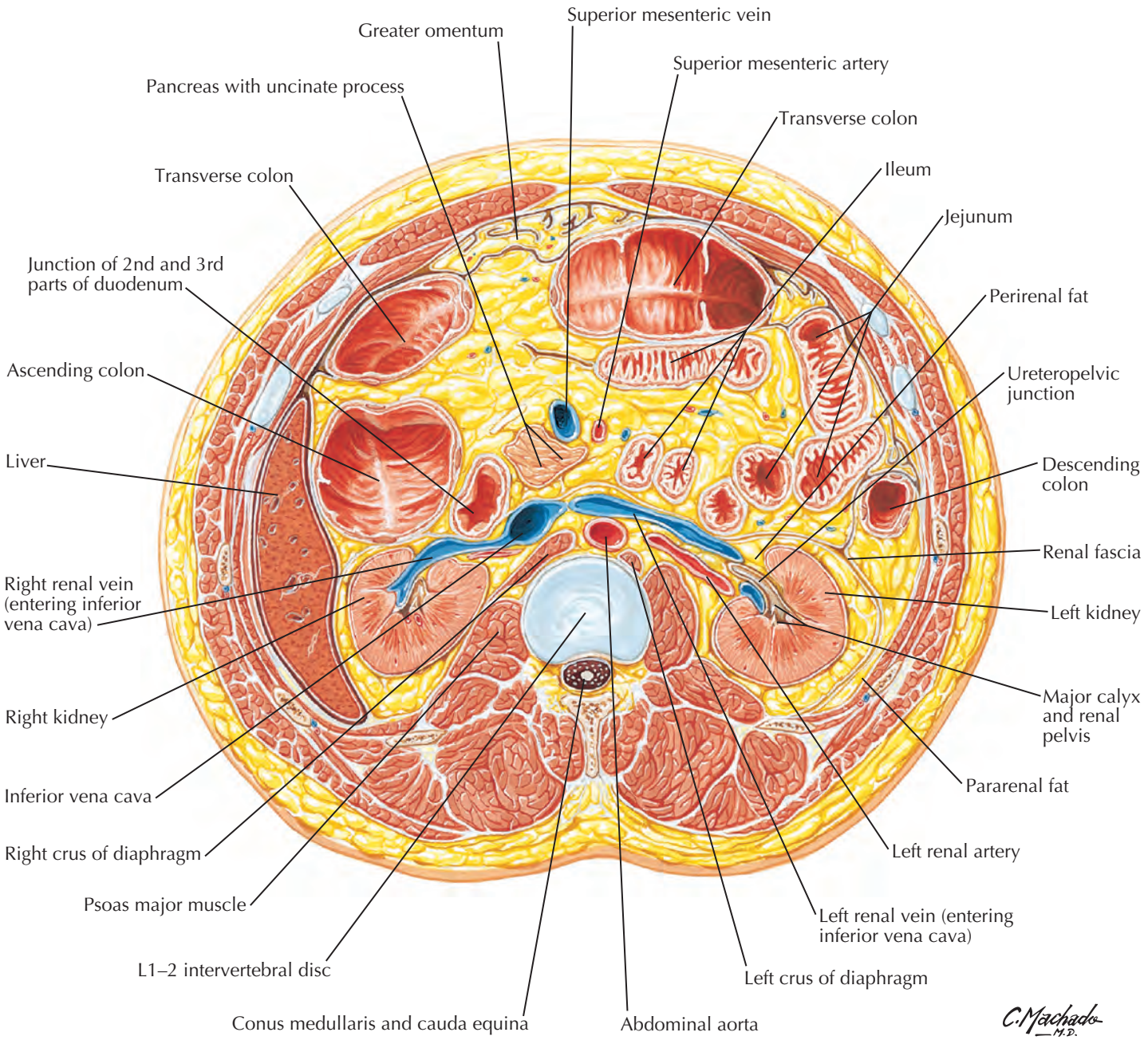

Pyloric canal
Stomach
Jejunum
Pylorus
Transverse colon (ascending to left colic flexure)
Right colic (hepatic) flexure of colon
Gallbladder
Trifurcation of celiac trunk
Superior (1st) part of duodenum
Descending colon (descending from left colic flexure)
Hepatoduodenal ligament
Liver
Spleen
Common bile duct
Portal triad
Hepatic artery proper
Splenic artery and vein
Portal vein
Left suprarenal gland
Inferior vena cava
Superior pole of left kidney
Right suprarenal gland
Left crus of diaphragm
Right crus of diaphragm
Thoracic aorta
Pancreas
C. Machado M.D.

Cross Section at T12–L1, Intervertebral Disc

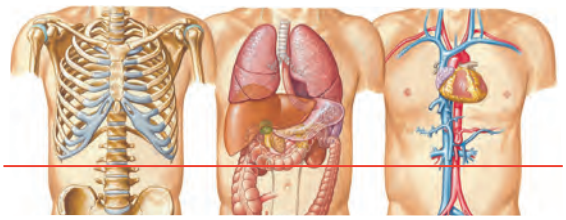


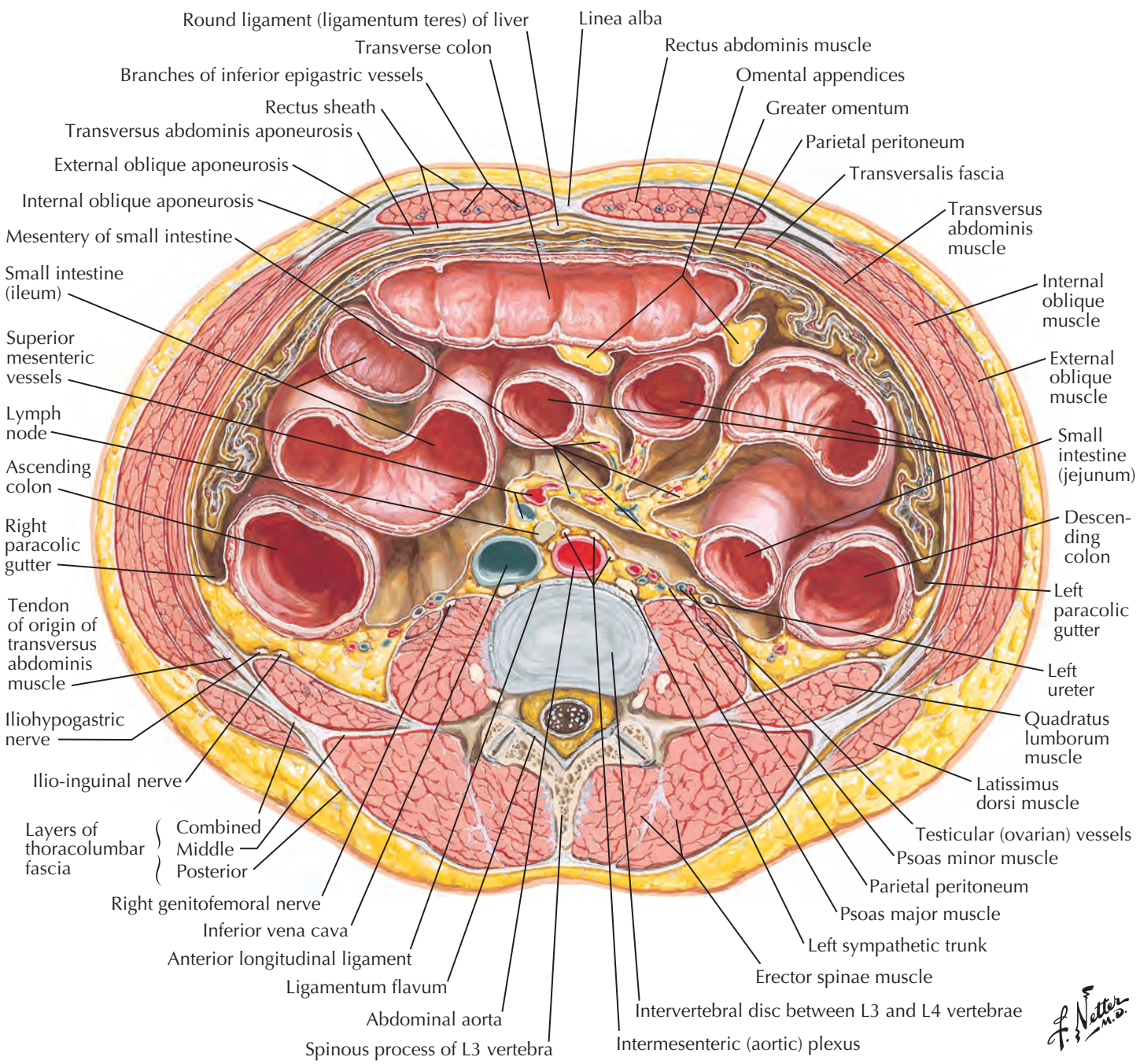





Greater omentum
Superior mesenteric vein
Superior mesenteric artery
Pancreas with uncinate process
Transverse colon
Transverse colon
Ileum
Jejunum
Junction of 2nd and 3rd parts of duodenum
Perirenal fat
Ascending colon
Ureteropelvic junction
Liver
Descending colon
Renal fascia
Right renal vein (entering inferior vena cava)
Left kidney
Right kidney
Major calyx and renal pelvis
Pararenal fat
Inferior vena cava
Right crus of diaphragm
Left renal artery
Psoas major muscle
Left renal vein (entering inferior vena cava)
L1–2 intervertebral disc
Left crus of diaphragm
Conus medullaris and cauda equina
Abdominal aorta
C. Machado M.D.

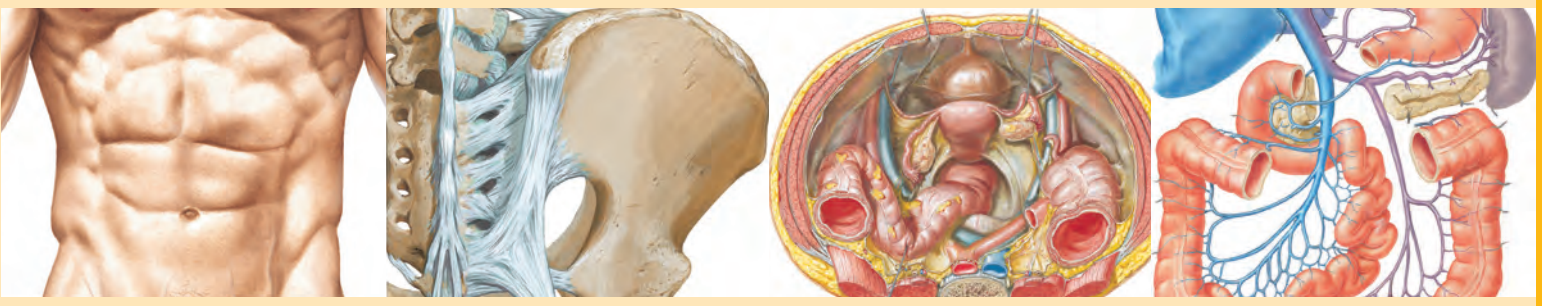
Cross Section at L3–4





MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Diaphragm	Xiphoid process, lower six costal cartilages, L1–L3 vertebrae	Converges into central tendon	Phrenic nerve	Draws central tendon down and forward during inspiration	Pericardiacophrenic, musculophrenic, superior and inferior phrenic arteries	Posterior abdominal wall
External oblique	External surfaces of ribs 5–12	Linea alba, pubic tubercle, anterior half of iliac crest	Ventral rami of six inferior thoracic nerves	Compresses and supports abdominal viscera, flexes and rotates trunk	Superior and inferior epigastric arteries	Abdominal wall
Iliacus	Superior 2/3 iliac fossa, ala of sacrum, anterior sacro-iliac ligaments	Lesser trochanter of femur and shaft inferior to it, and to psoas major tendon	Femoral nerve	Flexes hip and stabilizes hip joint; acts with psoas major	Iliac branches of iliolumbar artery	Posterior abdominal wall
Internal oblique	Thoracolumbar fascia, anterior 2/3 of iliac crest, lateral half of inguinal ligament	Inferior borders of ribs 10–12, linea alba, pubis via conjoint tendon	Ventral rami of six inferior thoracic and first lumbar nerves	Compresses and supports abdominal viscera, flexes and rotates trunk	Superior and inferior epigastric and deep circumflex iliac arteries	Abdominal wall
Psoas major	Transverse processes of lumbar vertebrae, sides of bodies of T12–L5 vertebrae, intervening intervertebral discs	Lesser trochanter of femur	Ventral rami of first four lumbar nerves	Acting superiorly with iliacus, flexes hip; acting inferiorly, flexes vertebral column laterally; used to balance trunk in sitting position; acting inferiorly with iliacus, flexes trunk	Lumbar branches of iliolumbar artery	Posterior abdominal wall
Psoas minor	Vertebral margins of T12–L1 vertebrae, corresponding intervertebral disc	Pectineal line, iliopectineal eminence	Ventral rami of first lumbar nerve	Flexes pelvis on vertebral column	Lumbar branch of iliolumbar artery	Posterior abdominal wall
Pyramidalis	Body of pubis, anterior to rectus abdominis	Linea alba	Iliohypogastric nerve	Tenses linea alba	Inferior epigastric artery	Abdominal wall
Quadratus lumborum	Medial half of inferior border of 12th rib, tips of lumbar transverse processes	Iliolumbar ligament, internal lip of iliac crest	Ventral rami of T12 and first four lumbar nerves	Extends and laterally flexes vertebral column, fixes 12th rib during inspiration	Iliolumbar artery	Posterior abdominal wall
Rectus abdominis	Pubic symphysis, pubic crest	Xiphoid process, costal cartilages 5–7	Ventral rami of six inferior thoracic nerves	Flexes trunk, compresses abdominal viscera	Superior and interior epigastric arteries	Abdominal wall
Transversus abdominis	Internal surfaces of costal cartilages 7–12, thoracolumbar fascia, iliac crest, lateral third of inguinal ligament	Linea alba with aponeurosis of internal oblique, pubic crest, and pecten pubis via conjoint tendon	Ventral rami of six inferior thoracic and first lumbar nerves	Compresses and supports abdominal viscera	Deep circumflex iliac and inferior epigastric arteries	Abdominal wall

Variations in spinal nerve contributions to the innervation of muscles, their arterial supply, their attachments, and their actions are common themes in human anatomy. Therefore, expect differences between texts and realize that anatomical variation is normal.



Section 5

5 PELVIS AND PERINEUM

Topographic Anatomy
Plate 329

329 Pelvis and Perineum: Surface Anatomy

Bones and Ligaments
Plates 330–334

330 Bony Framework of Pelvis
331 Radiographs of Male and Female Pelvis
332 Sex Differences of Pelvis: Measurements
333 Bones and Ligaments of Pelvis
334 Bones and Ligaments of Pelvis (continued)

Pelvic Floor and Contents
Plates 335–345

335 Pelvic Diaphragm: Female
336 Pelvic Diaphragm: Female (continued)
337 Pelvic Diaphragm: Female (continued)
338 Pelvic Diaphragm: Male
339 Pelvic Diaphragm: Male (continued)
340 Pelvic Viscera and Perineum: Female
341 Pelvic Contents: Female
342 Pelvic Viscera: Female
343 Endopelvic Fascia and Potential Spaces
344 Pelvic Viscera and Perineum: Male
345 Pelvic Contents: Male

Urinary Bladder

Plates 346–348

346 Urinary Bladder: Orientation and Supports

347 Female Sphincters

348 Urinary Bladder: Female and Male

Uterus, Vagina, and Supporting Structures

Plates 349–353

349 Uterine Growth

350 Uterus, Vagina, and Supporting Structures

351 Uterus: Fascial Ligaments

352 Uterus and Adnexa

353 Pelvic Ligaments

Perineum and External Genitalia: Female

Plates 354–357

354 Female Perineum and External Genitalia (Pudendum or Vulva)

355 Female Perineum (Superficial Dissection)

356 Female Perineum and Deep Perineum

357 Female Perineal Spaces

Perineum and External Genitalia: Male

Plates 358–365

358 Male Perineum and External Genitalia (Superficial Dissection)

359 Male Perineum and External Genitalia (Deeper Dissection)

360 Penis

361 Male Perineal Spaces

362 Prostate and Seminal Vesicles

363 Urethra

364 Descent of Testis

365 Scrotum and Contents

Homologues of Genitalia

Plates 366–367

366 Homologues of External Genitalia

367 Homologues of Internal Genitalia

Testis, Epididymis, and Ductus Deferens

Plate 368

368 Testis, Epididymis, and Ductus Deferens

Rectum

Plates 369–374

369 Rectum in Situ: Female and Male

370 Ischio-anal Fossae

371 Rectum and Anal Canal

372 Anorectal Musculature

373 External Anal Sphincter Muscle: Perineal Views

374 Actual and Potential Perineopelvic Spaces

Regional Scans

Plate 375

375 Pelvic Scans: Sagittal CT Images

Vasculature

Plates 376–386

376 Arteries of Rectum and Anal Canal: Male

377 Veins of Rectum and Anal Canal: Female

378 Arteries and Veins of Pelvic Organs: Female

379 Arteries and Veins of Testis

380 Arteries of Pelvis: Female

381 Arteries and Veins of Pelvis: Male

382 Arteries and Veins of Perineum and Uterus

383 Arteries and Veins of Perineum: Male

384 Lymph Vessels and Nodes of Pelvis and Genitalia: Female

385 Lymph Vessels and Nodes of Perineum: Female

386 Lymph Vessels and Nodes of Pelvis and Genitalia: Male

Innervation

Plates 387–395

387 Nerves of External Genitalia: Male

388 Nerves of Pelvic Viscera: Male

389 Nerves of Perineum: Male

390 Nerves of Pelvic Viscera: Female

391 Nerves of Perineum and External Genitalia: Female

392 Neuropathways in Parturition

393 Innervation of Female Reproductive Organs: Schema

394 Innervation of Male Reproductive Organs: Schema

395 Innervation of Urinary Bladder and Lower Ureter: Schema

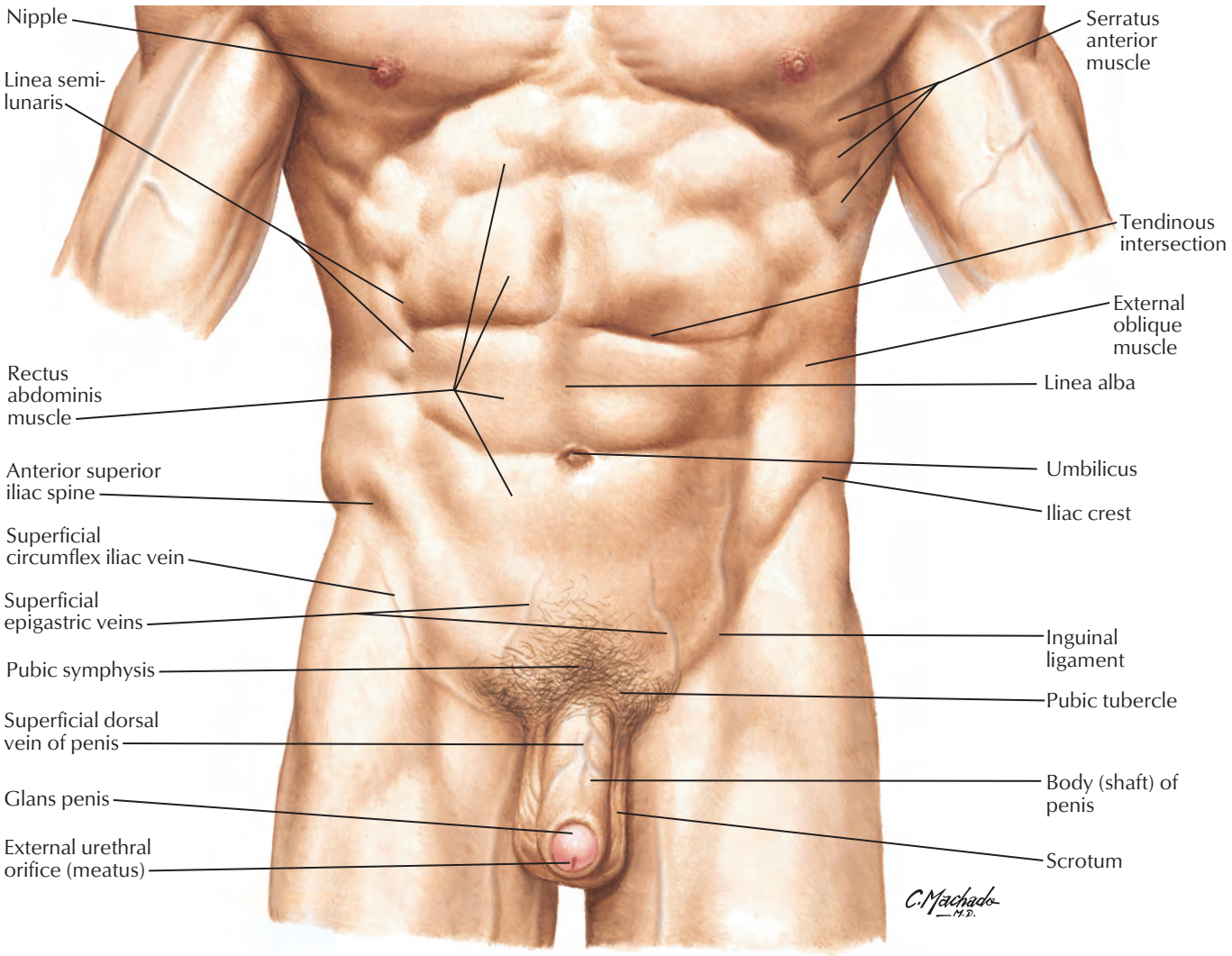
Cross-Sectional Anatomy

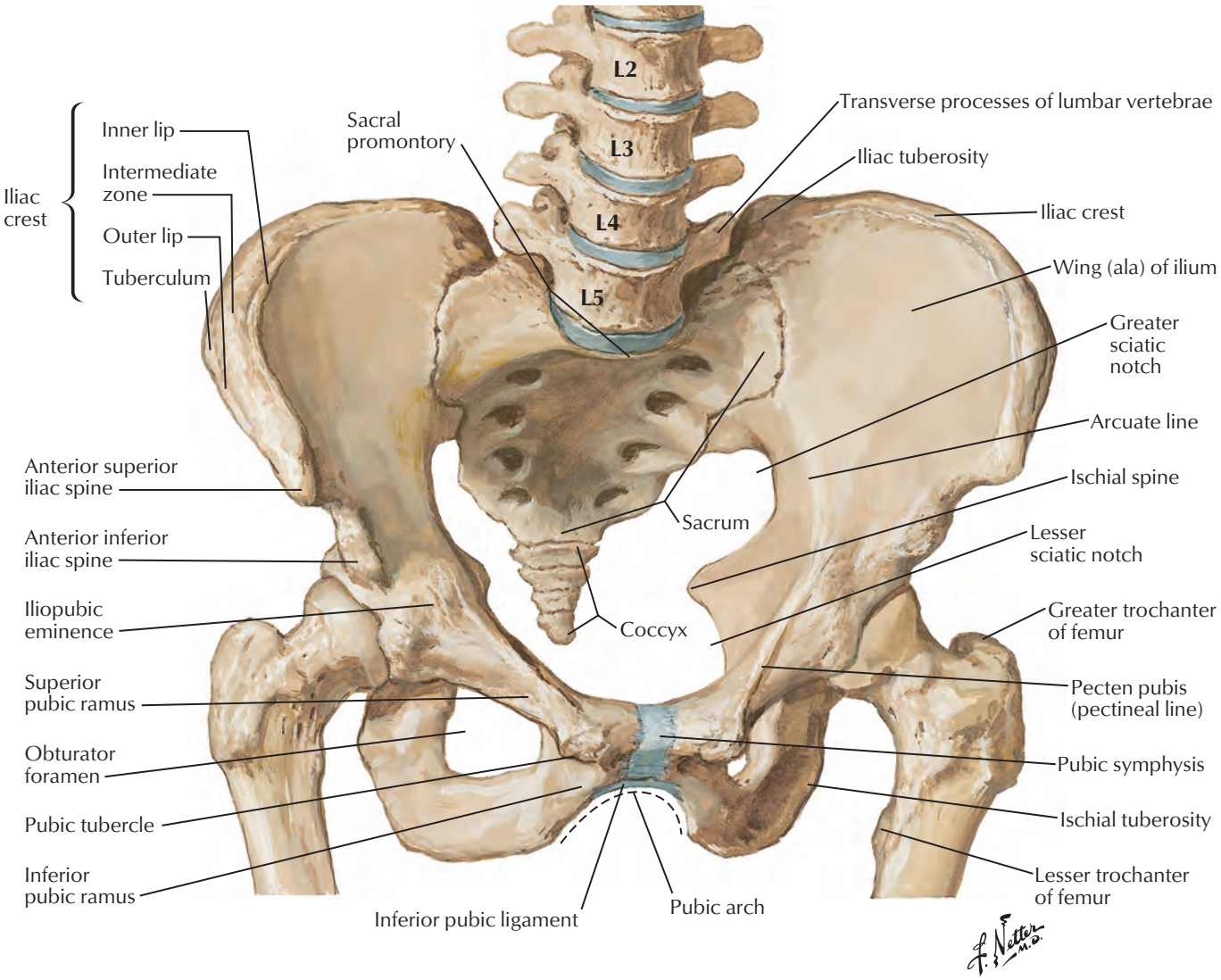
Plates 396–397

396 Male Pelvis: Cross Section of Bladder-Prostate Junction

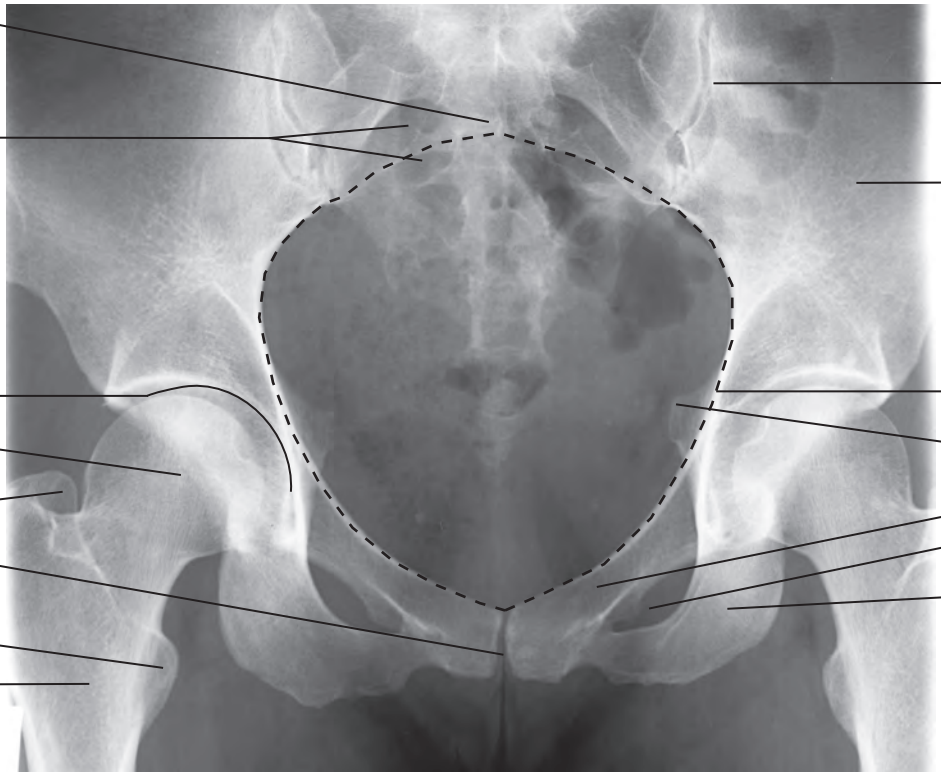
397 Female Pelvis: Cross Section of Vagina-Urethra

Muscle Tables

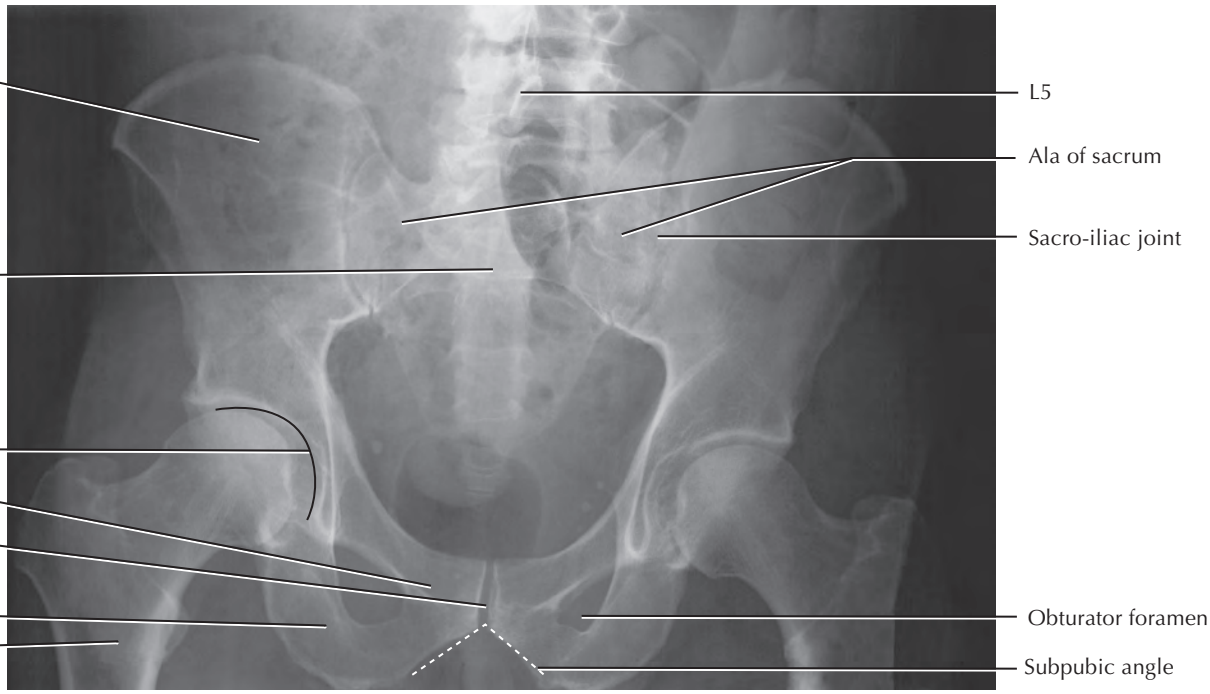

Nipple
Linea semi-lunaris
Rectus abdominis muscle
Anterior superior iliac spine
Superficial circumflex iliac vein
Superficial epigastric veins
Pubic symphysis
Superficial dorsal vein of penis
Glans penis
External urethral orifice (meatus)
Serratus anterior muscle
Tendinous intersection
External oblique muscle
Linea alba
Umbilicus
Iliac crest
Inguinal ligament
Pubic tubercle
Body (shaft) of penis
Scrotum
C. Machado M.D.


L2
L3
L4
L5
Sacral promontory
Transverse processes of lumbar vertebrae
Iliac tuberosity
Iliac crest
Wing (ala) of ilium
Greater sciatic notch
Arcuate line
Ischial spine
Lesser sciatic notch
Greater trochanter of femur
Pecten pubis (pectineal line)
Pubic symphysis
Ischial tuberosity
Lesser trochanter of femur
Iliac crest
Inner lip
Intermediate zone
Outer lip
Tuberculum
Anterior superior iliac spine
Anterior inferior iliac spine
Iliopubic eminence
Superior pubic ramus
Obturator foramen
Pubic tubercle
Inferior pubic ramus
Sacrum
Coccyx
Inferior pubic ligament
Pubic arch

Female Pelvis

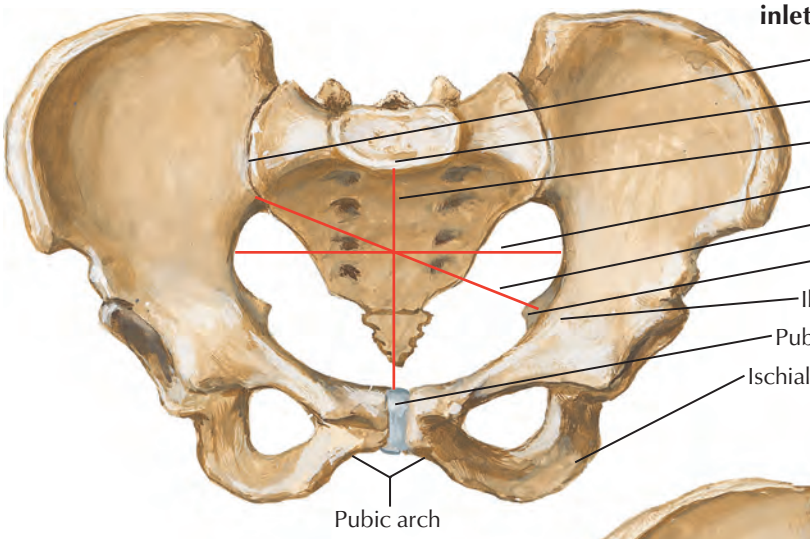


Male Pelvis

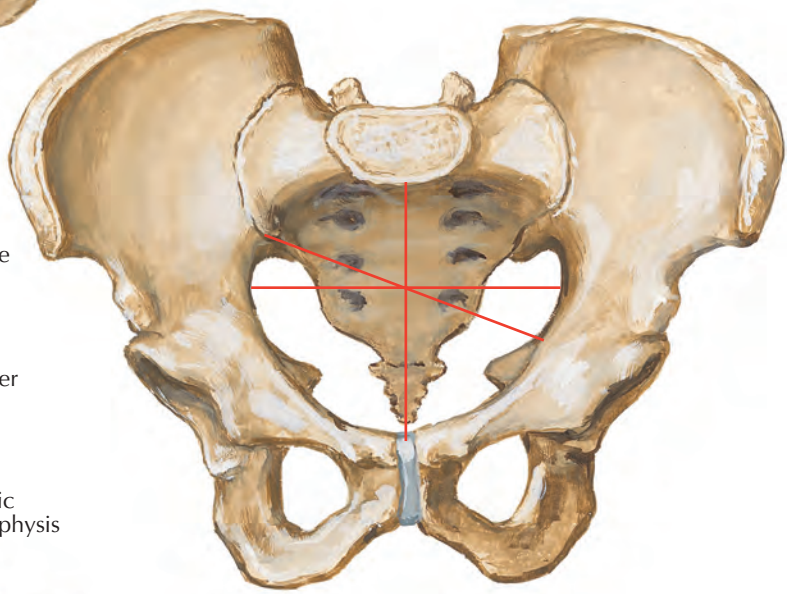


Sex Differences of Pelvis: Measurements

Female pelvis/female pelvic inlet: anterior view

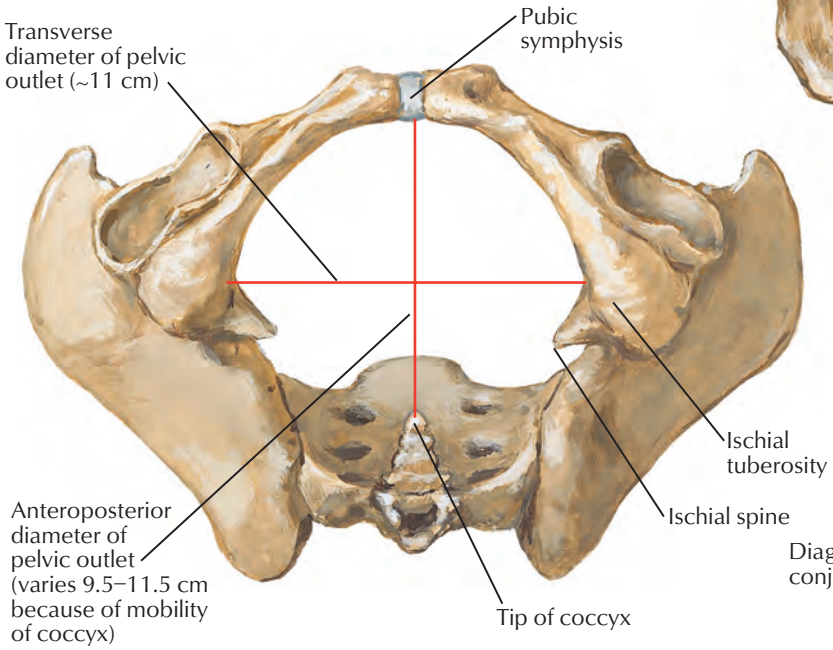


Male pelvis/male pelvic inlet: anterior view

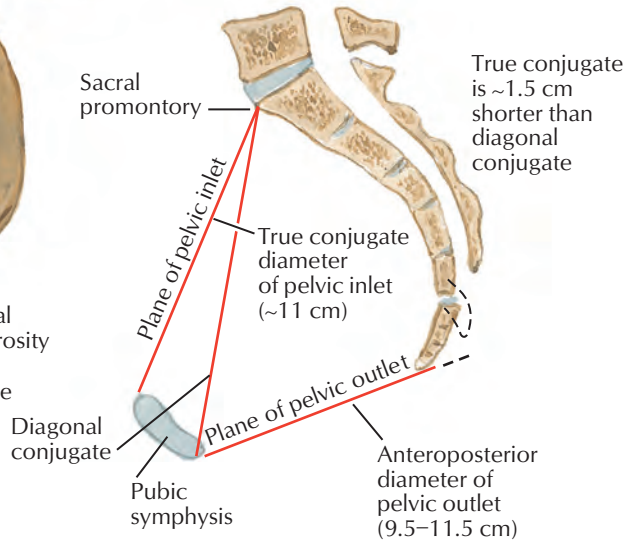


Diagonal conjugate is only diameter of pelvic inlet that can be measured clinically

- All measurements slightly shorter in relation to body size than in female
- Pelvic inlet oriented more antero-posteriorly than in female, where it tends to be transversely oval
- Pubic symphysis deeper (taller)
- Pubic arch (subpubic angle) narrower
- Ischial tuberosities less far apart
- Iliac wings less flared

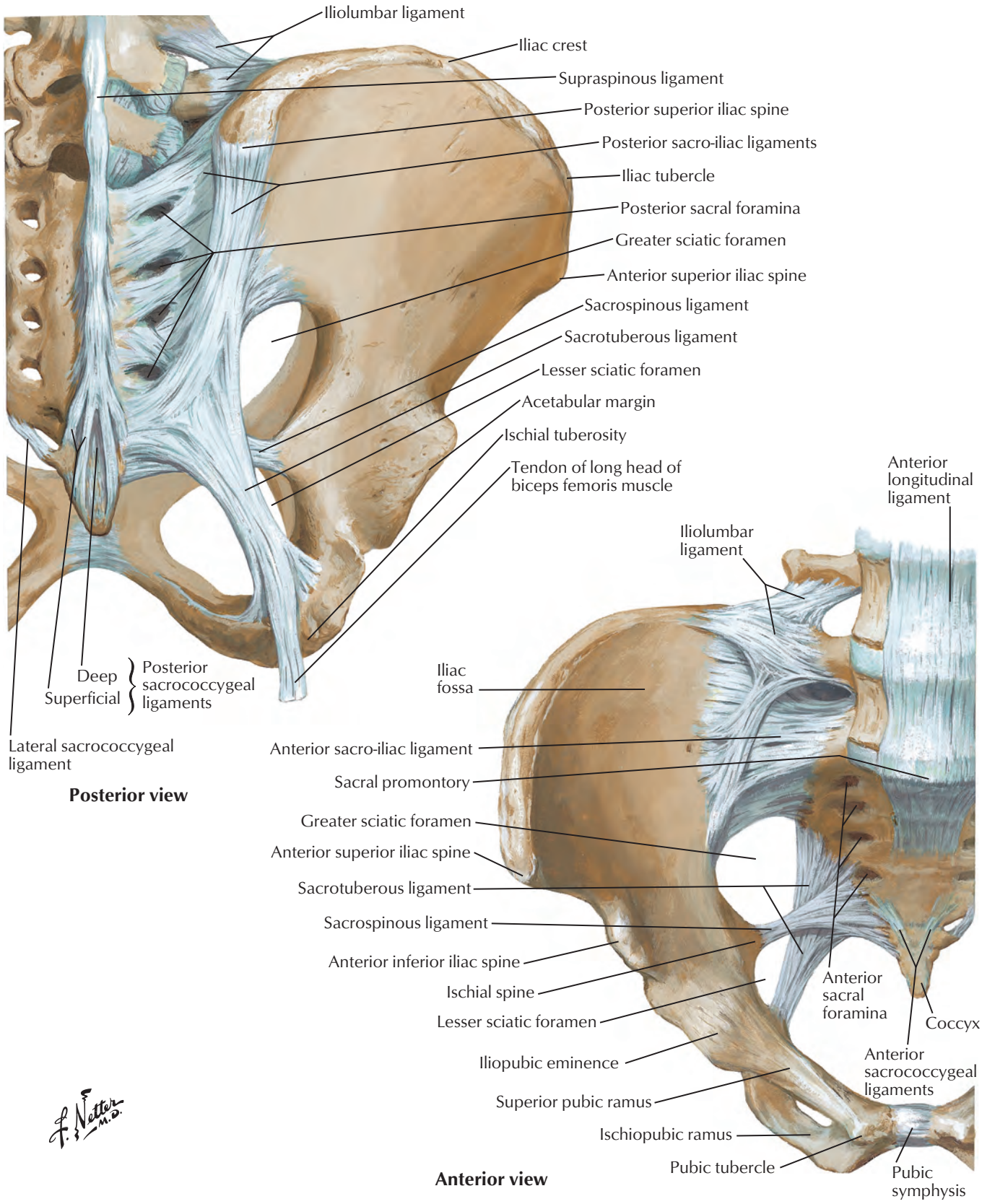


Female pelvis/female pelvic outlet: inferior view

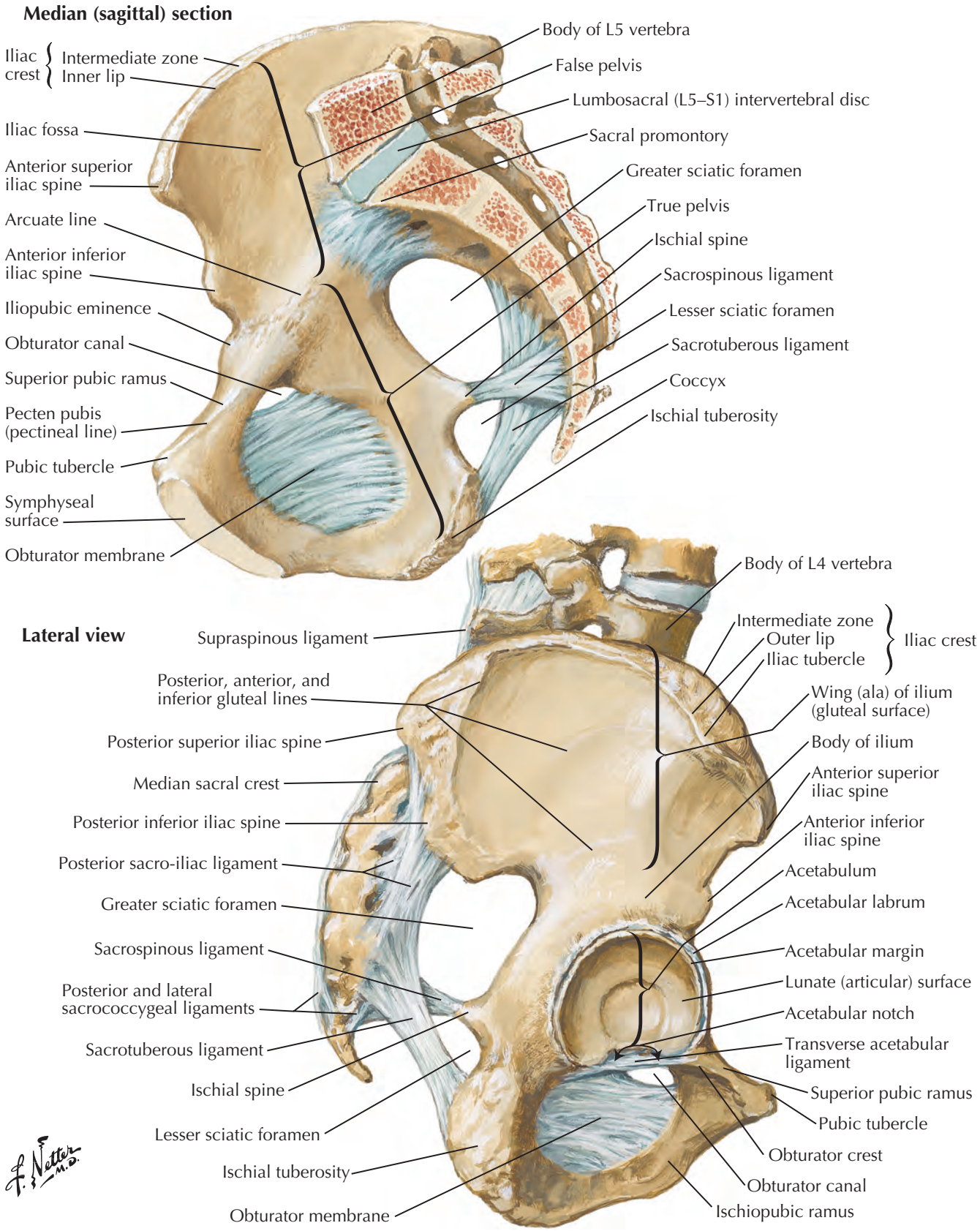


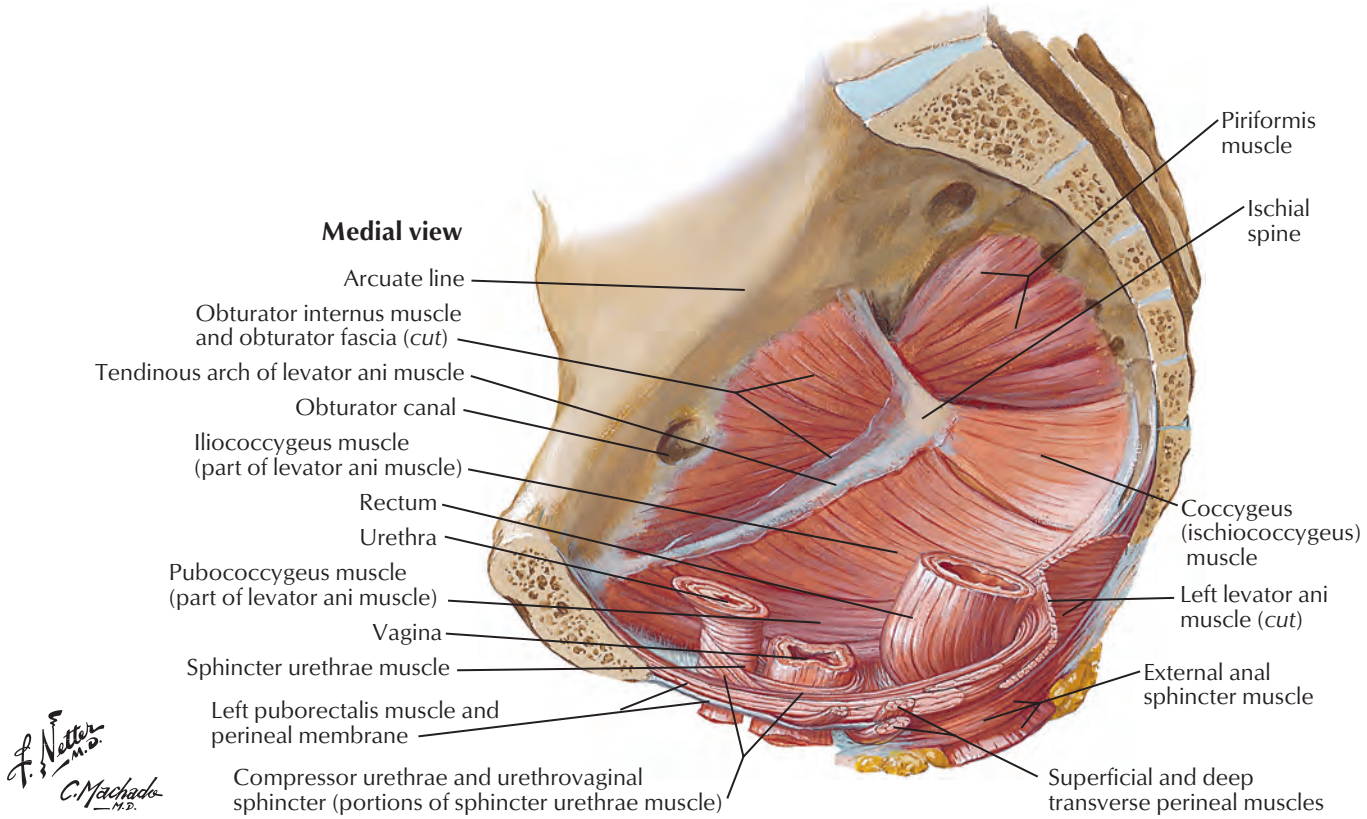
Transverse diameter is the widest distance of pelvic inlet

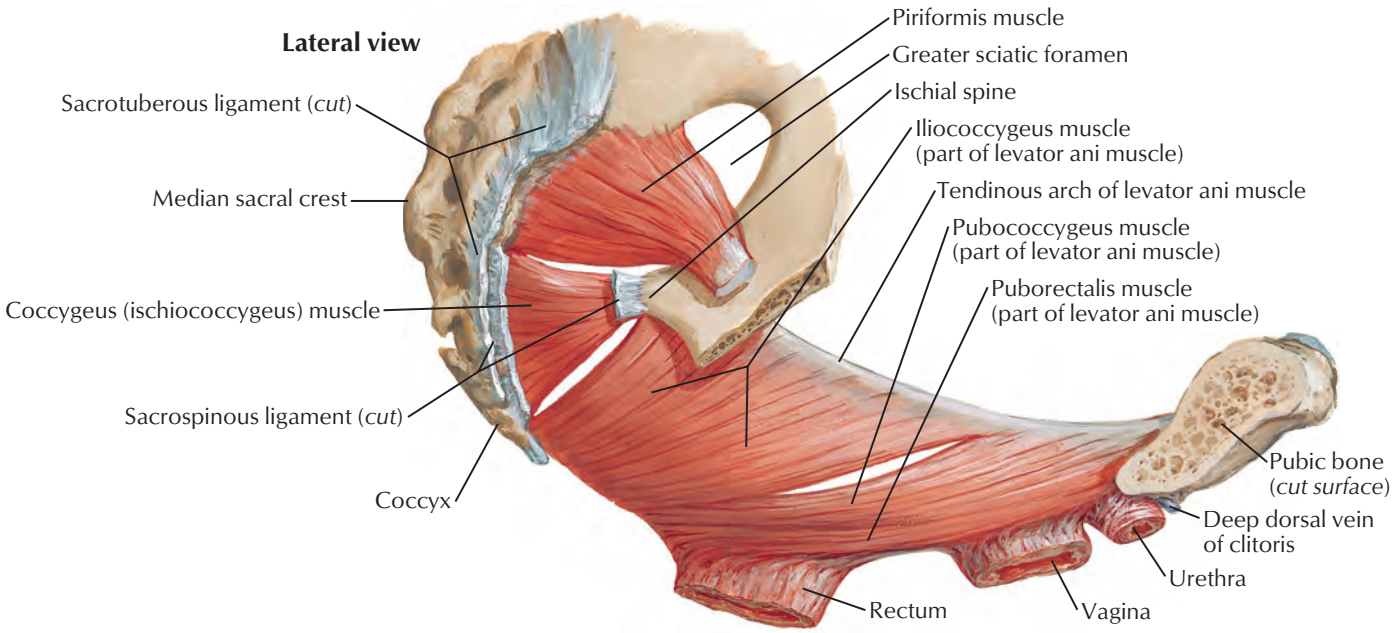
Female: sagittal section


Iliolumbar ligament
Iliac crest
Supraspinous ligament
Posterior superior iliac spine
Posterior sacro-iliac ligaments
Iliac tubercle
Posterior sacral foramina
Greater sciatic foramen
Anterior superior iliac spine
Sacrospinous ligament
Sacrotuberous ligament
Lesser sciatic foramen
Acetabular margin
Ischial tuberosity
Tendon of long head of biceps femoris muscle
Deep
Superficial
Posterior sacrococcygeal ligaments
Lateral sacrococcygeal ligament
Posterior view
Anterior longitudinal ligament
Iliolumbar ligament
Iliac fossa
Anterior sacro-iliac ligament
Sacral promontory
Greater sciatic foramen
Anterior superior iliac spine
Sacrotuberous ligament
Sacrospinous ligament
Anterior inferior iliac spine
Ischial spine
Lesser sciatic foramen
Iliopubic eminence
Superior pubic ramus
Ischiopubic ramus
Pubic tubercle
Anterior sacral foramina
Coccyx
Anterior sacrococcygeal ligaments
Pubic symphysis
Anterior view

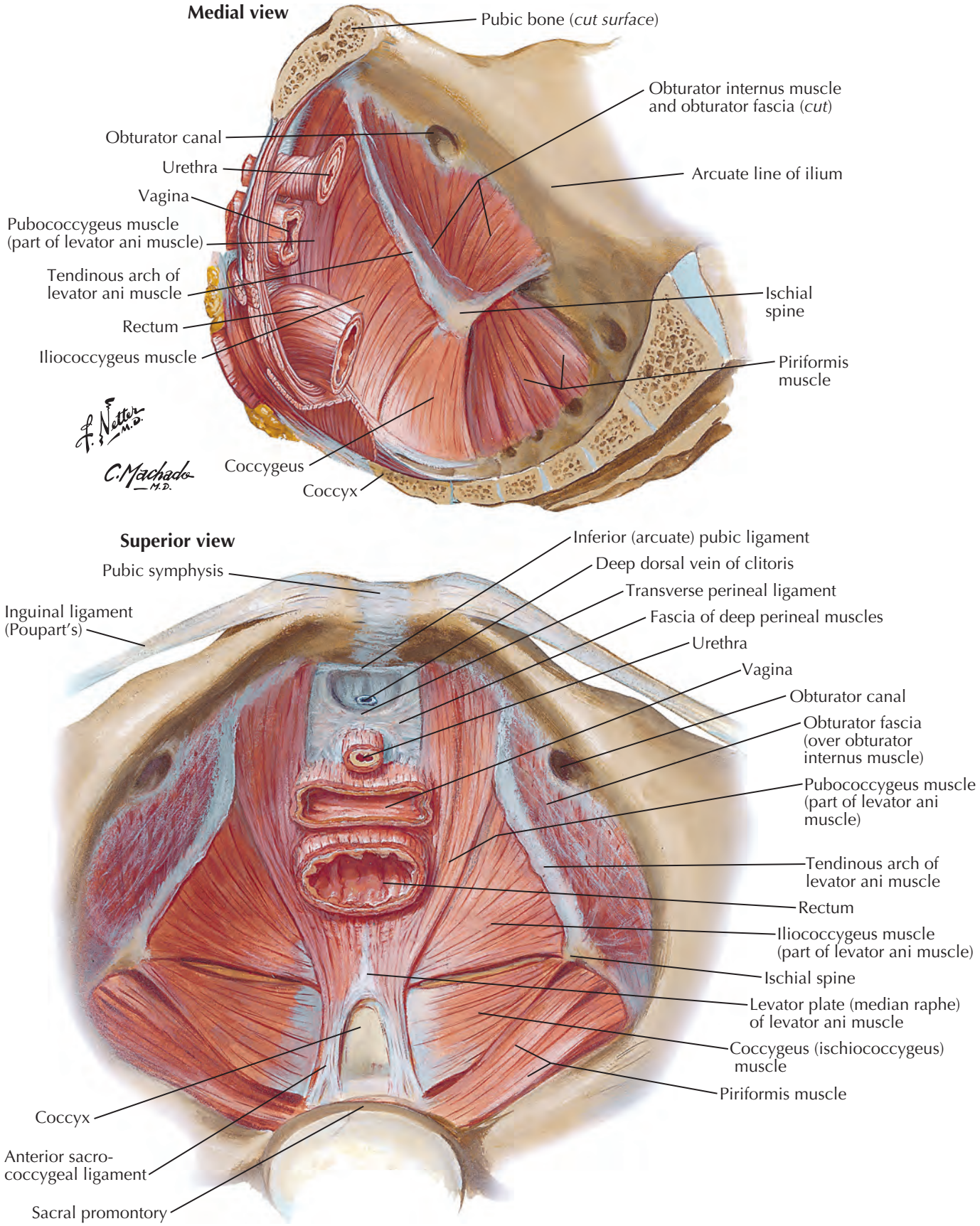
See also **Plate 158**

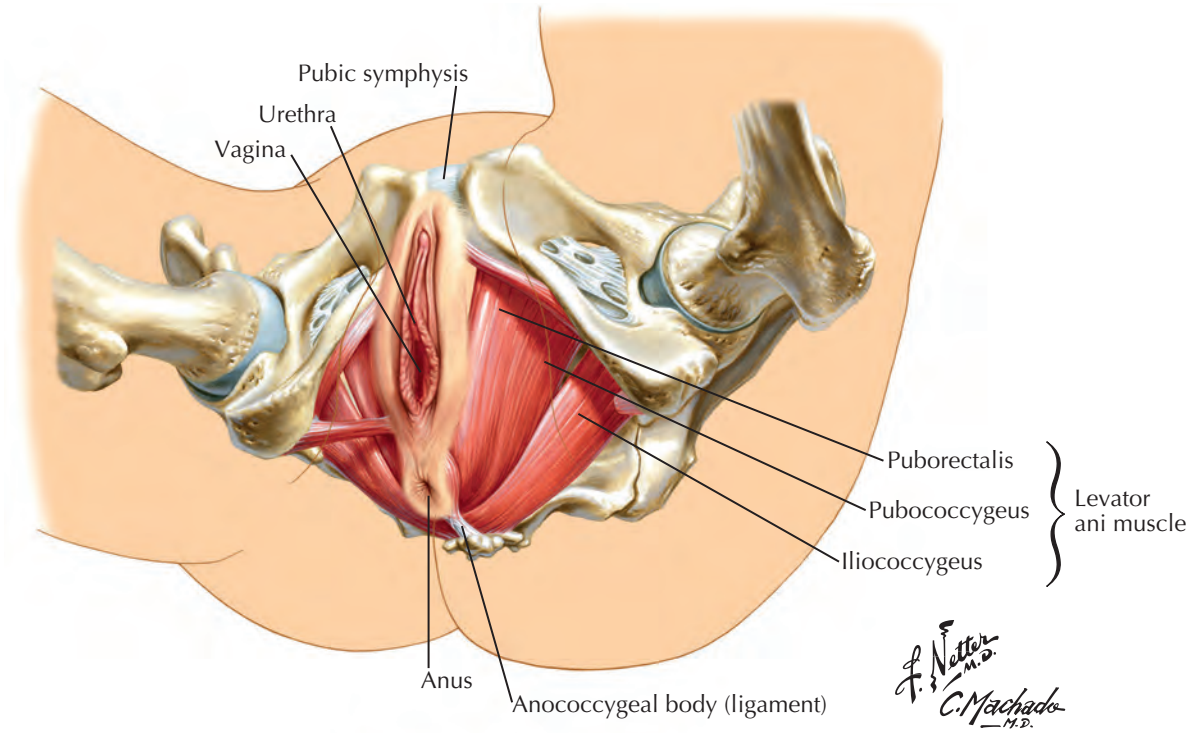



Medial view
Arcuate line
Obturator internus muscle and obturator fascia (cut)
Tendinous arch of levator ani muscle
Obturator canal
Iliococcygeus muscle (part of levator ani muscle)
Rectum
Urethra
Pubococcygeus muscle (part of levator ani muscle)
Vagina
Sphincter urethrae muscle
Left puborectalis muscle and perineal membrane
Compressor urethrae and urethrovaginal sphincter (portions of sphincter urethrae muscle)
Piriformis muscle
Ischial spine
Coccygeus (ischiococcygeus) muscle
Left levator ani muscle (cut)
External anal sphincter muscle
Superficial and deep transverse perineal muscles
F. Netter M.D.
C. Machado M.D.

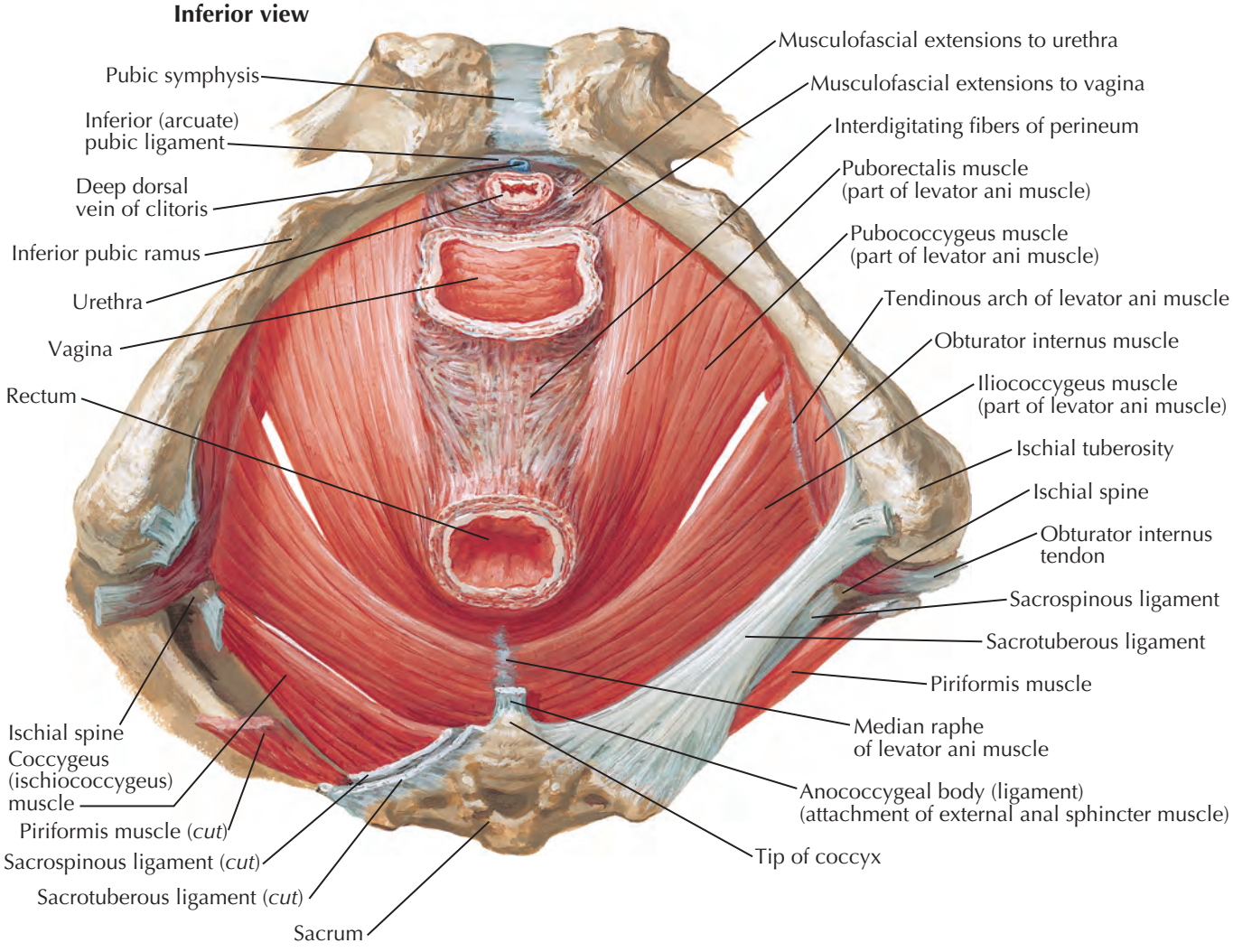

Lateral view
Sacrotuberous ligament (cut)
Median sacral crest
Coccygeus (ischiococcygeus) muscle
Sacrospinous ligament (cut)
Coccyx
Piriformis muscle
Greater sciatic foramen
Ischial spine
Iliococcygeus muscle (part of levator ani muscle)
Tendinous arch of levator ani muscle
Pubococcygeus muscle (part of levator ani muscle)
Puborectalis muscle (part of levator ani muscle)
Pubic bone (cut surface)
Deep dorsal vein of clitoris
Urethra
Vagina
Rectum

For urogenital diaphragm see **Plate 356**



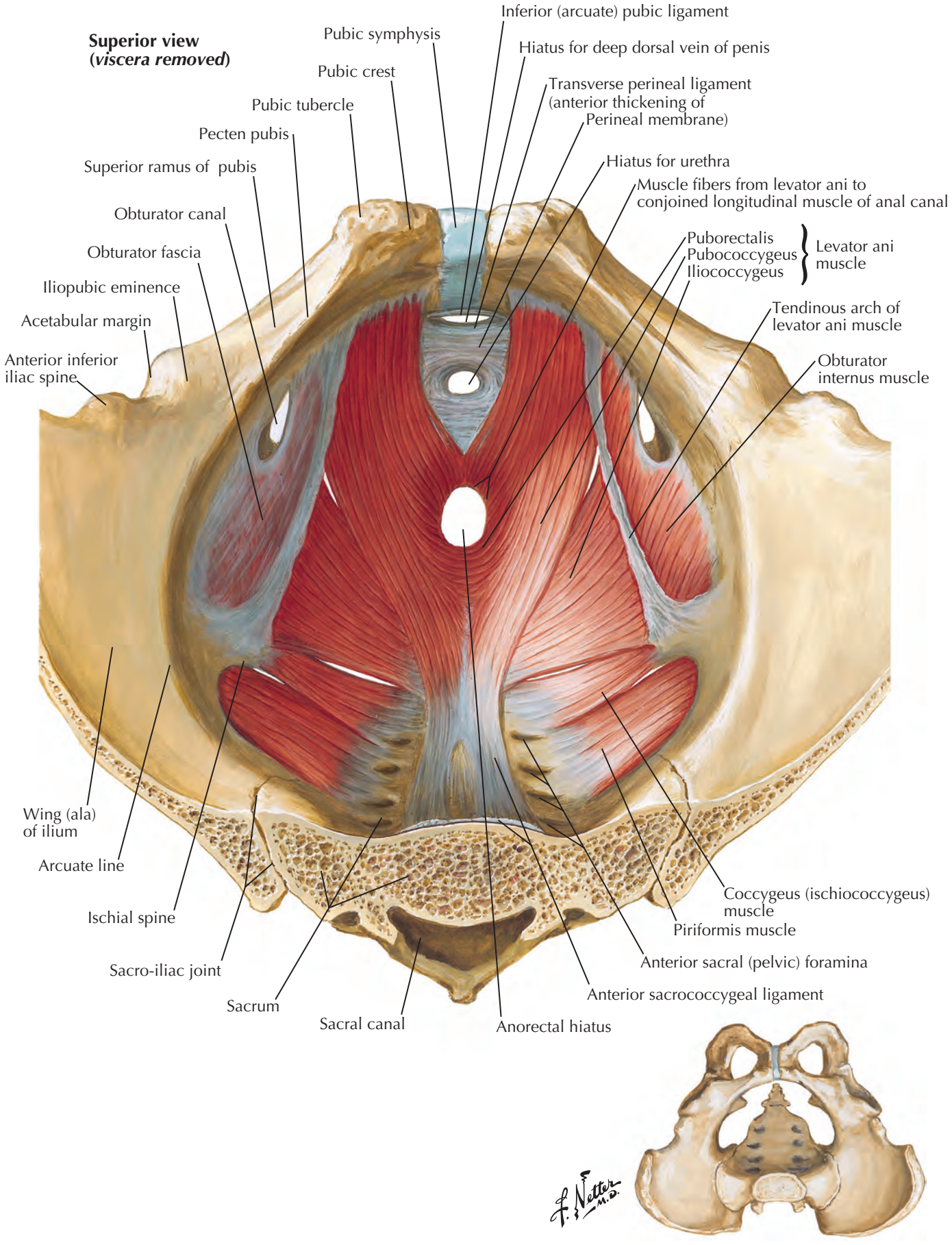


Inferior view



Pelvic Diaphragm: Male

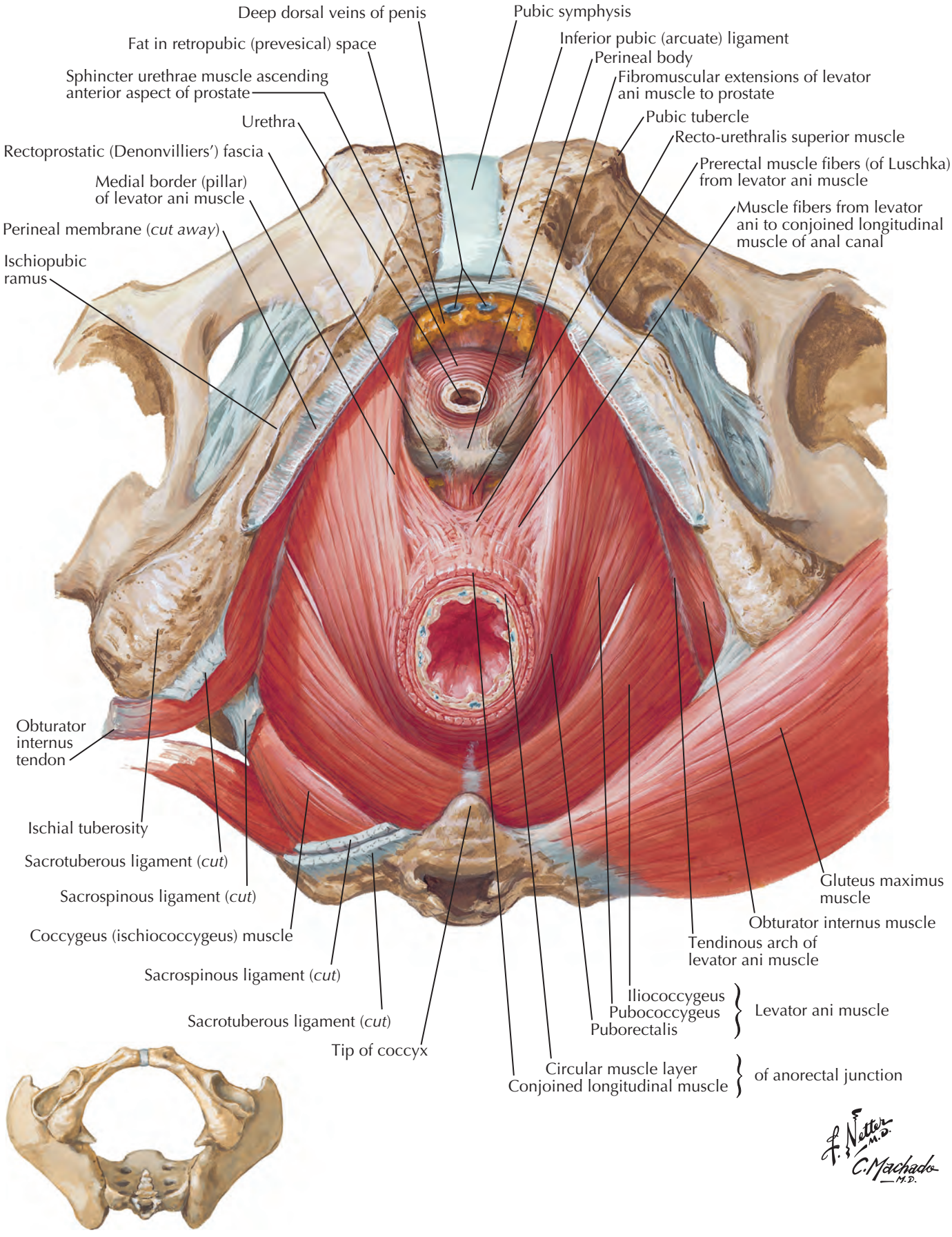
See also **Plates 258, 261**



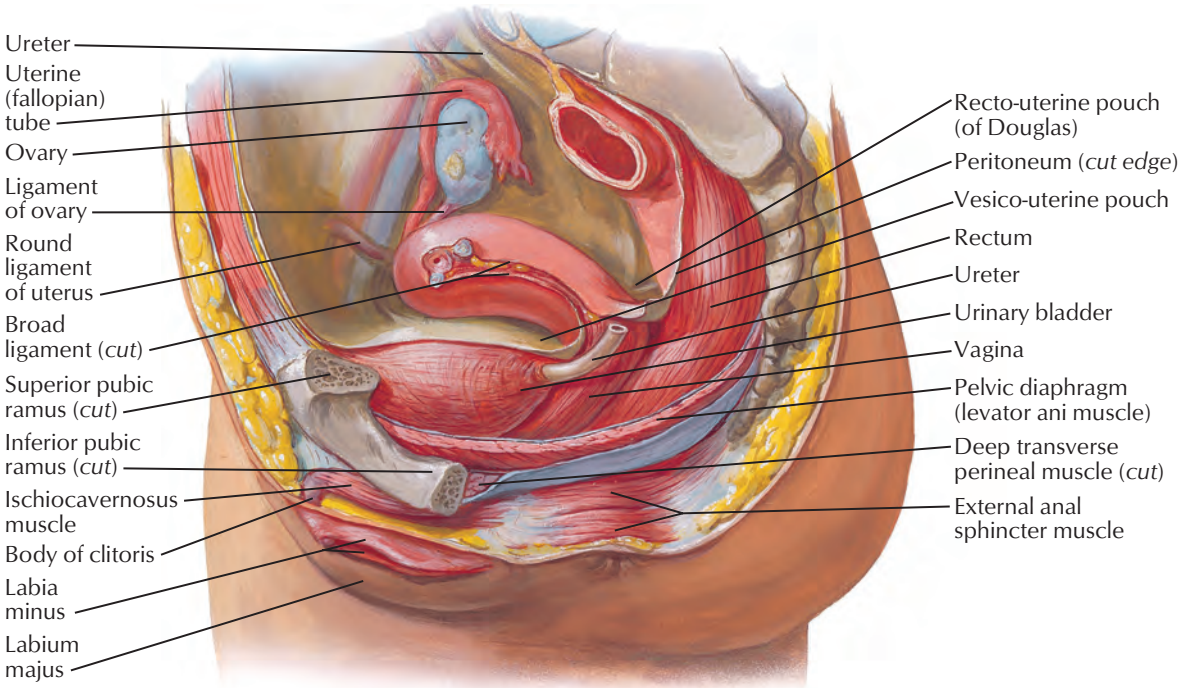
Pelvic Diaphragm: Male (continued)

For urogenital diaphragm see **Plate 361**

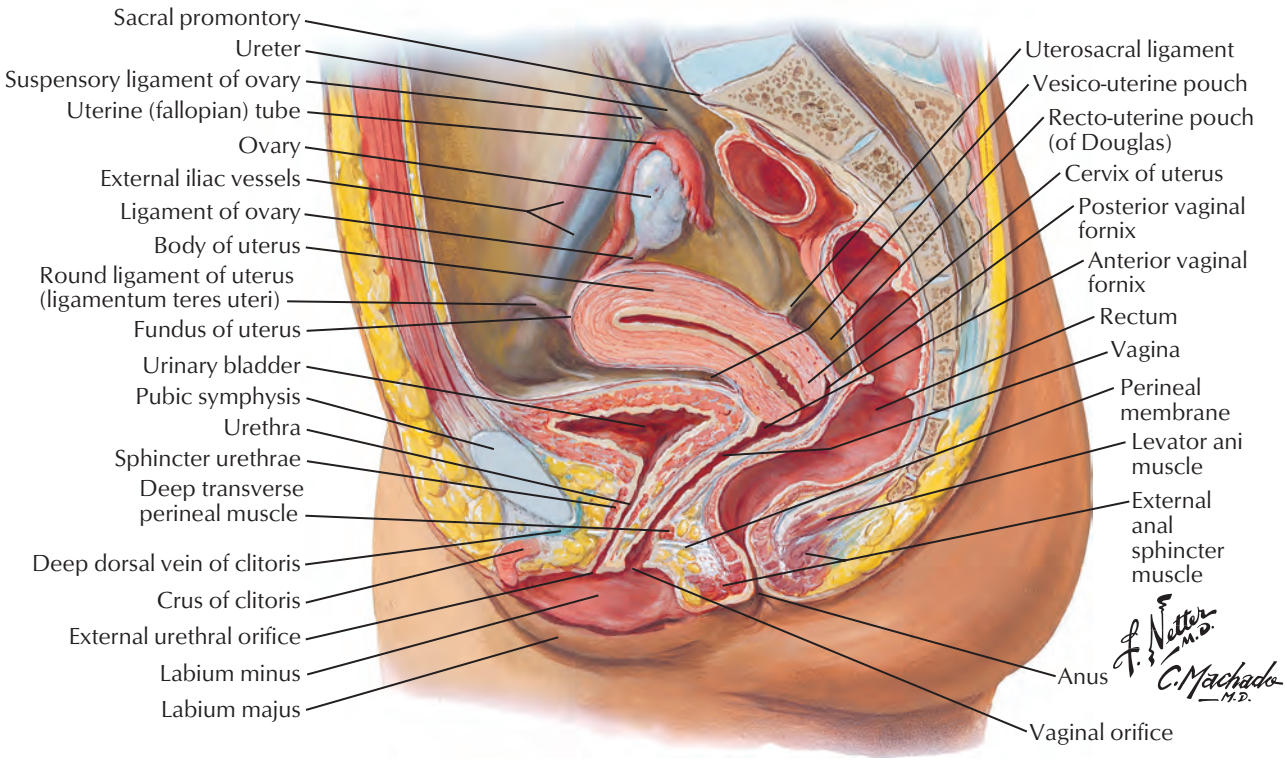
Inferior view

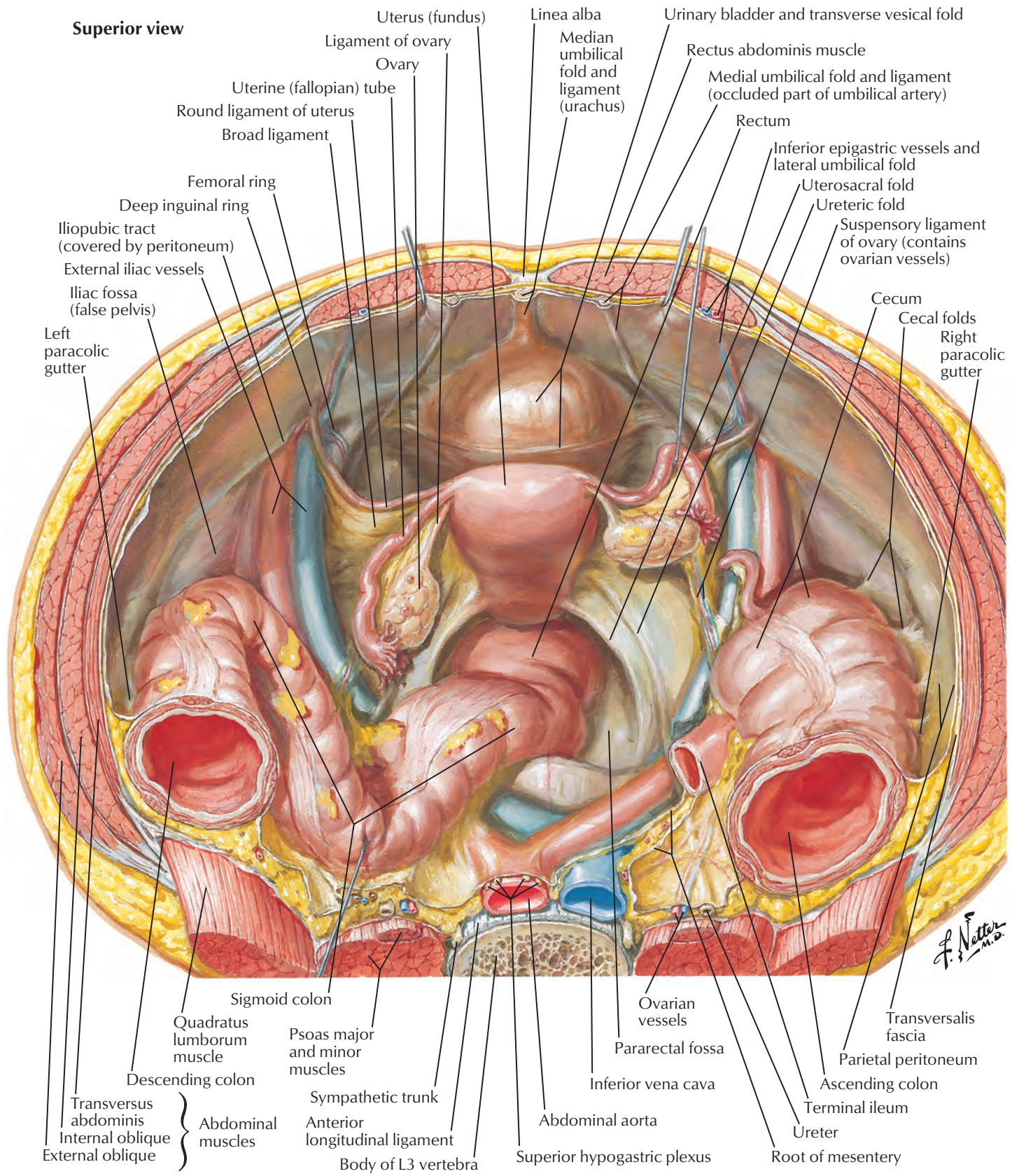


Paramedian (sagittal) dissection

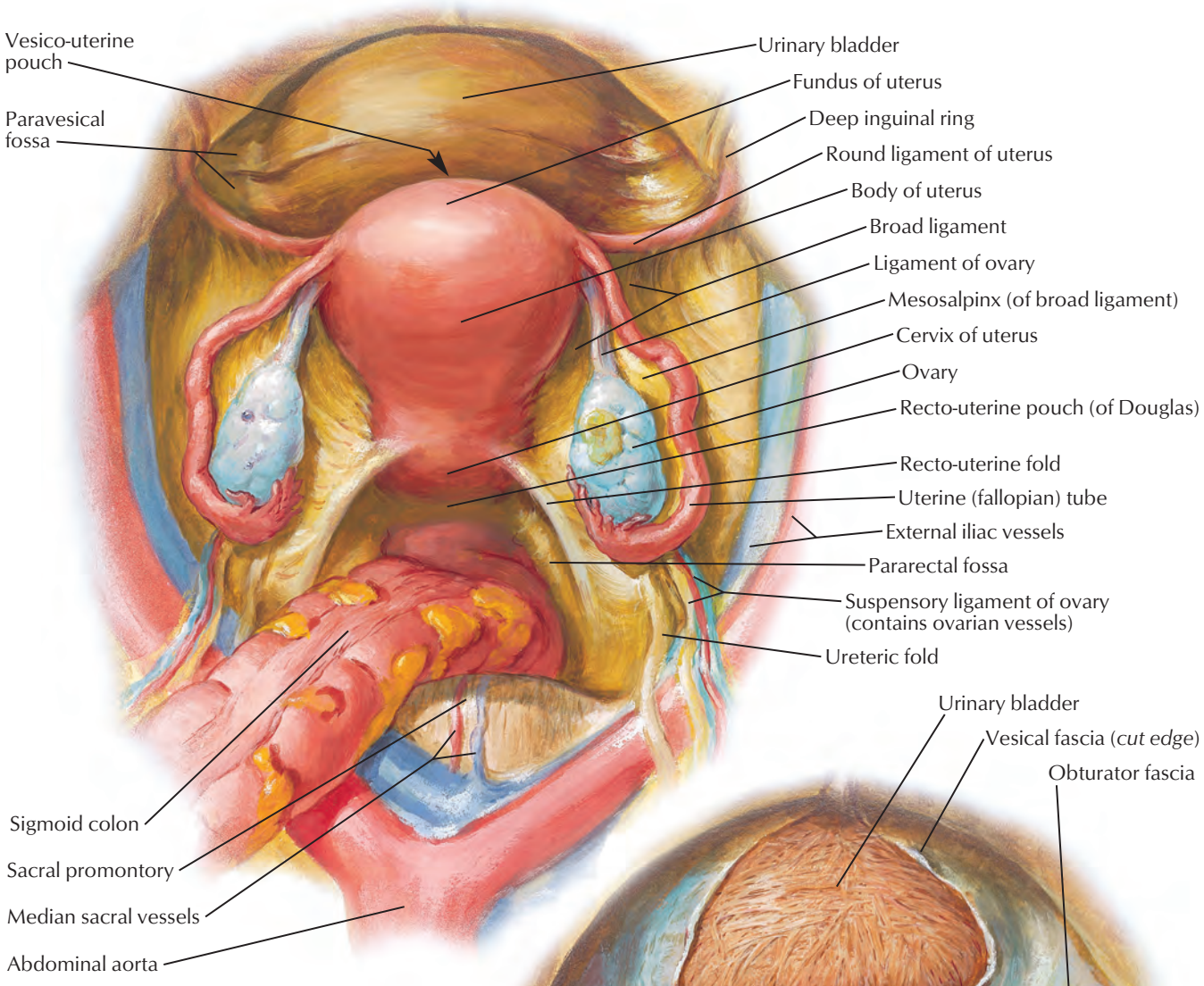


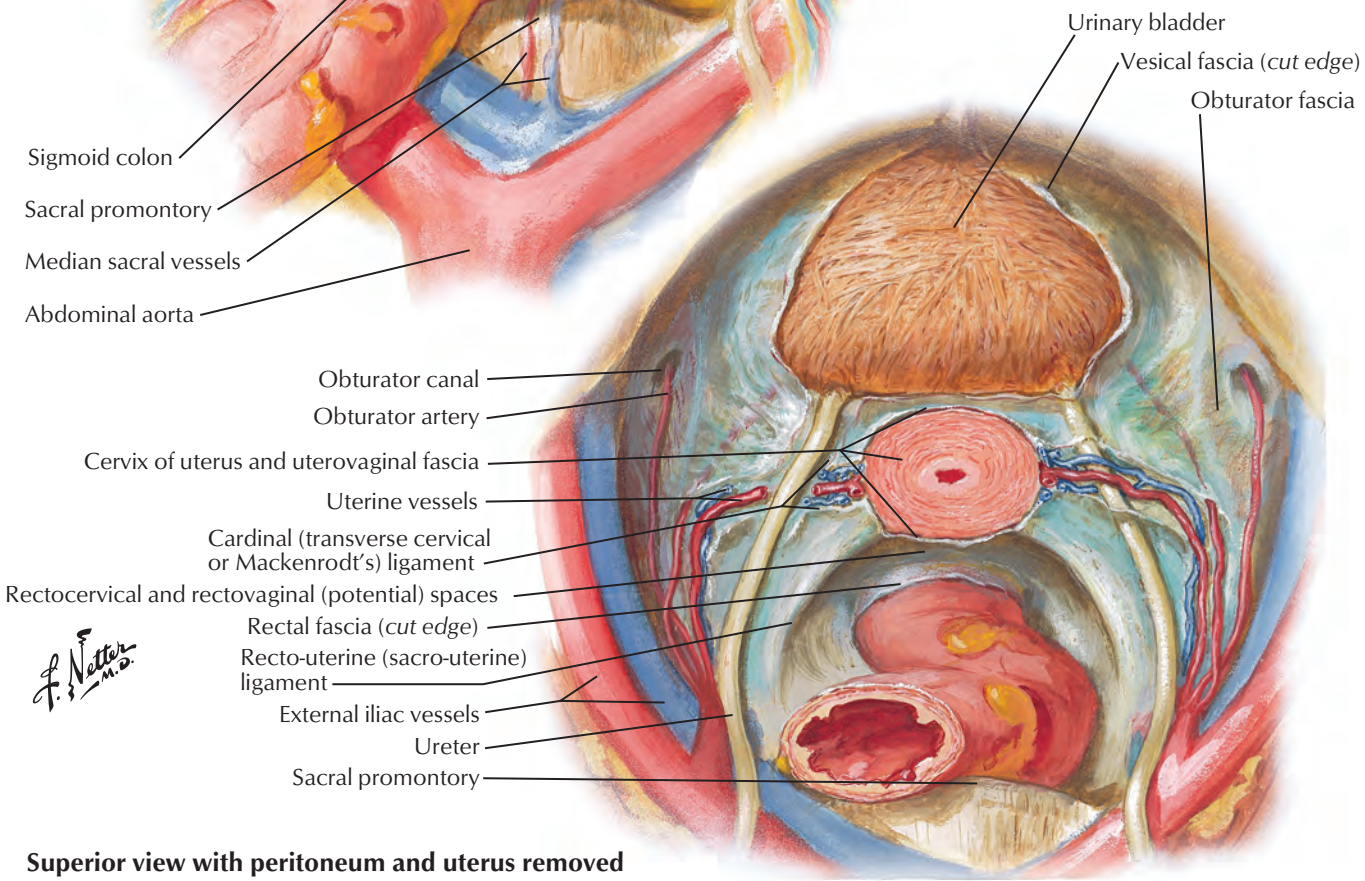
Median (sagittal) section




Superior view
Uterus (fundus)
Linea alba
Urinary bladder and transverse vesical fold
Ligament of ovary
Median umbilical fold and ligament (urachus)
Ovary
Rectus abdominis muscle
Uterine (fallopian) tube
Medial umbilical fold and ligament (occluded part of umbilical artery)
Round ligament of uterus
Rectum
Broad ligament
Inferior epigastric vessels and lateral umbilical fold
Femoral ring
Uterosacral fold
Deep inguinal ring
Ureteric fold
Iliopubic tract (covered by peritoneum)
Suspensory ligament of ovary (contains ovarian vessels)
External iliac vessels
Iliac fossa (false pelvis)
Cecum
Cecal folds
Left paracolic gutter
Right paracolic gutter
Sigmoid colon
Quadratus lumborum muscle
Psoas major and minor muscles
Ovarian vessels
Transversalis fascia
Pararectal fossa
Parietal peritoneum
Descending colon
Inferior vena cava
Ascending colon
Transversus abdominis
Sympathetic trunk
Terminal ileum
Internal oblique
Abdominal muscles
Abdominal aorta
Ureter
External oblique
Anterior longitudinal ligament
Root of mesentery
Body of L3 vertebra
Superior hypogastric plexus

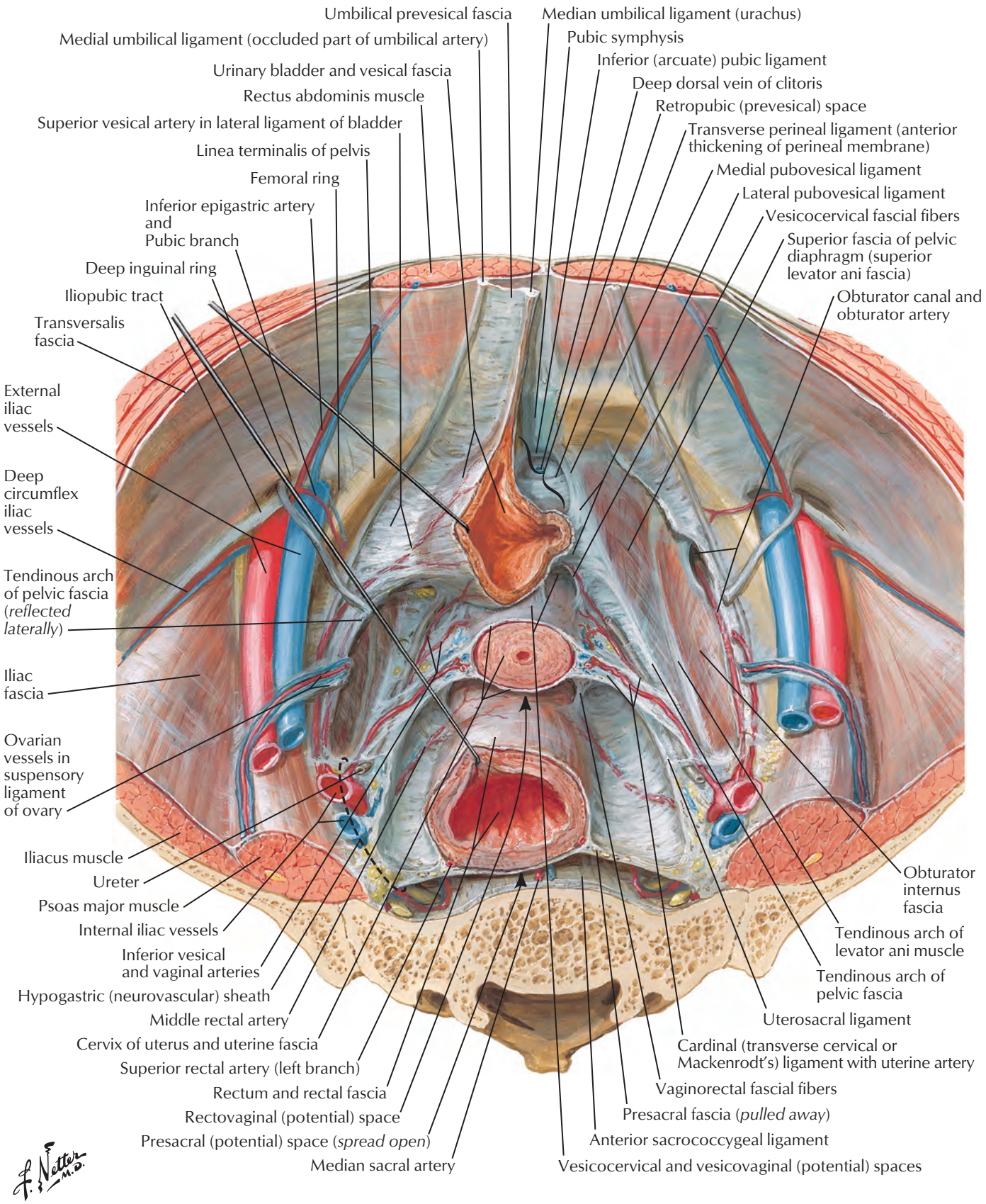
Superior view with peritoneum intact

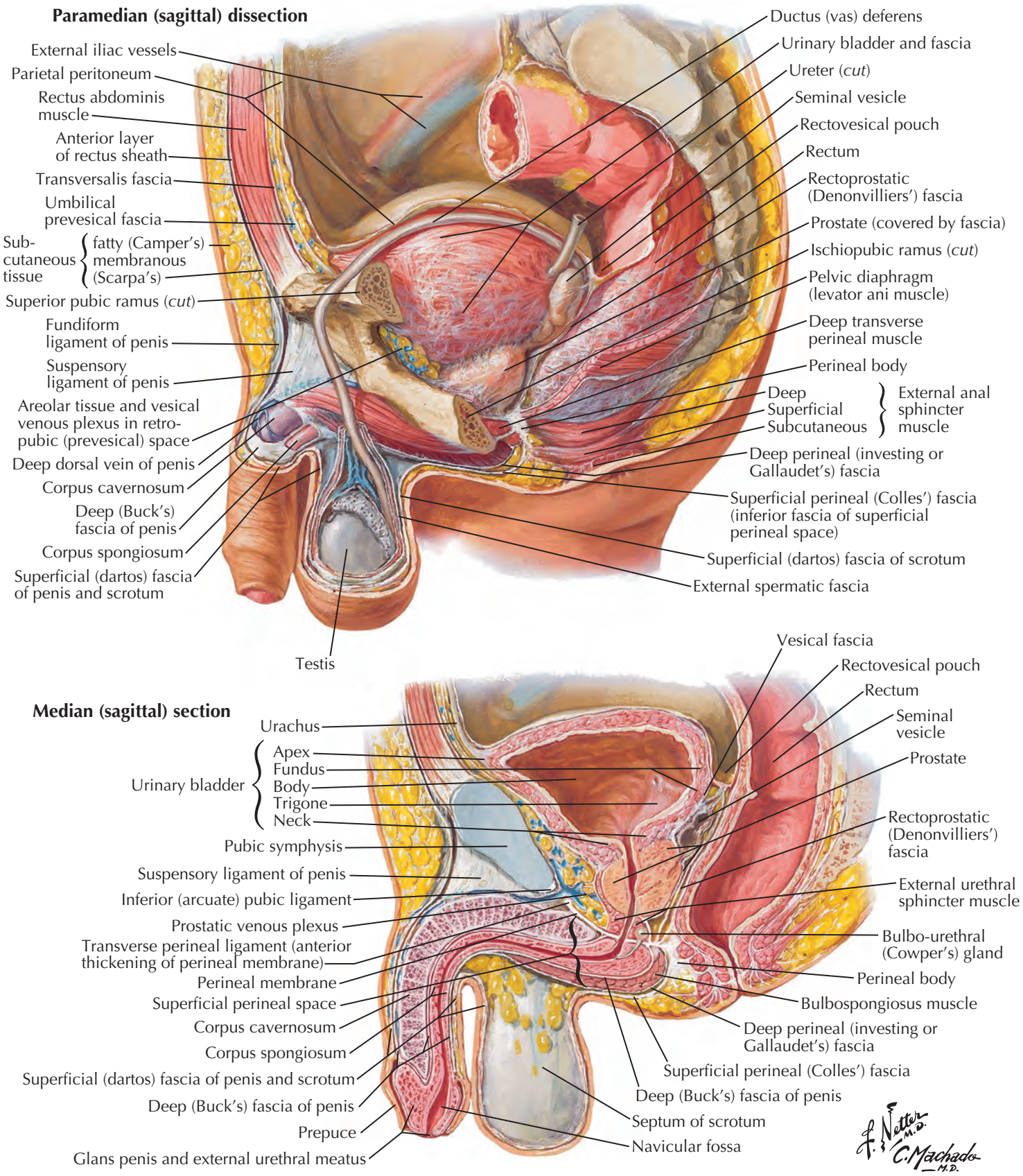




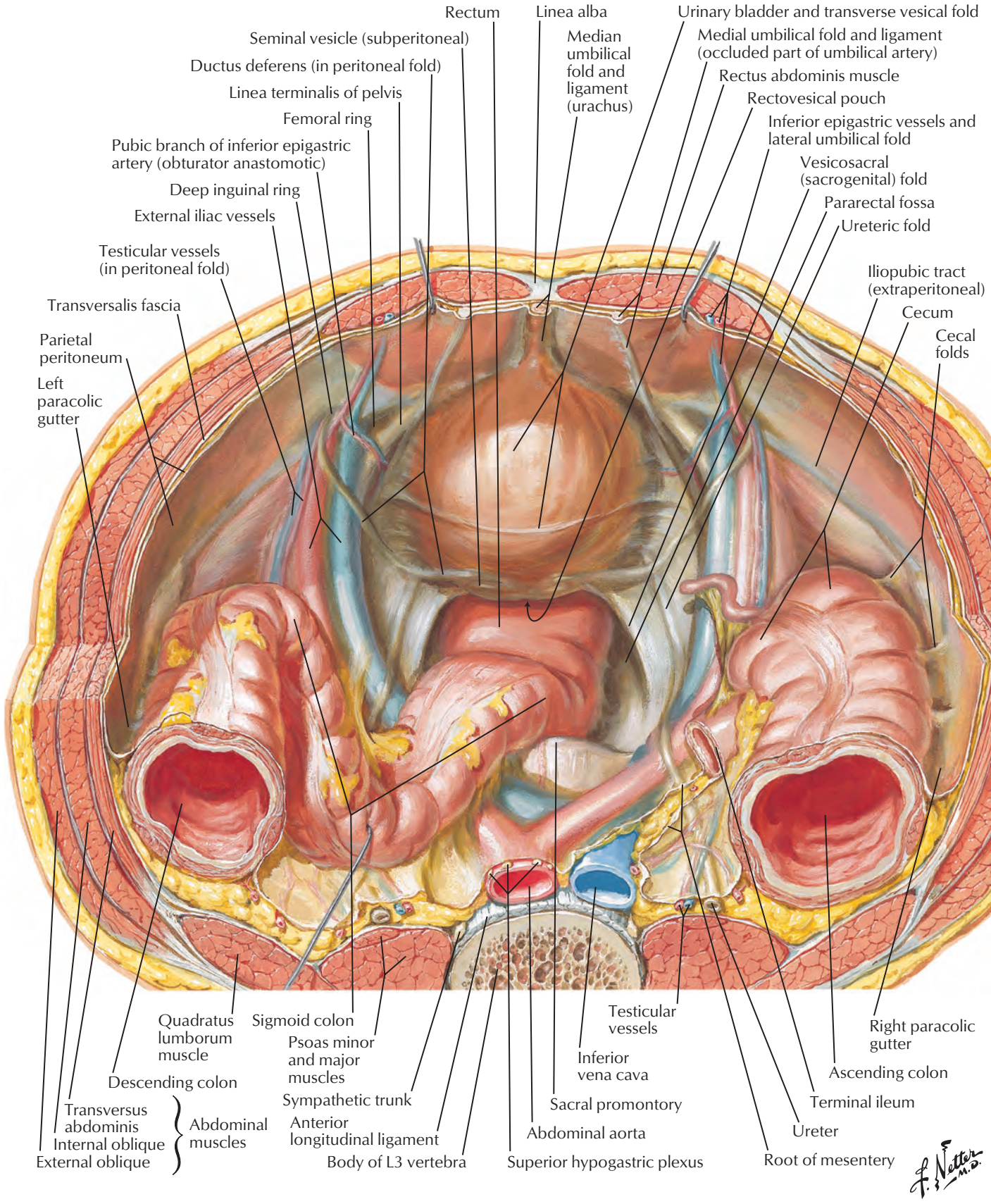
Superior view with peritoneum and uterus removed

Female: superior view (peritoneum and loose areolar tissue removed)

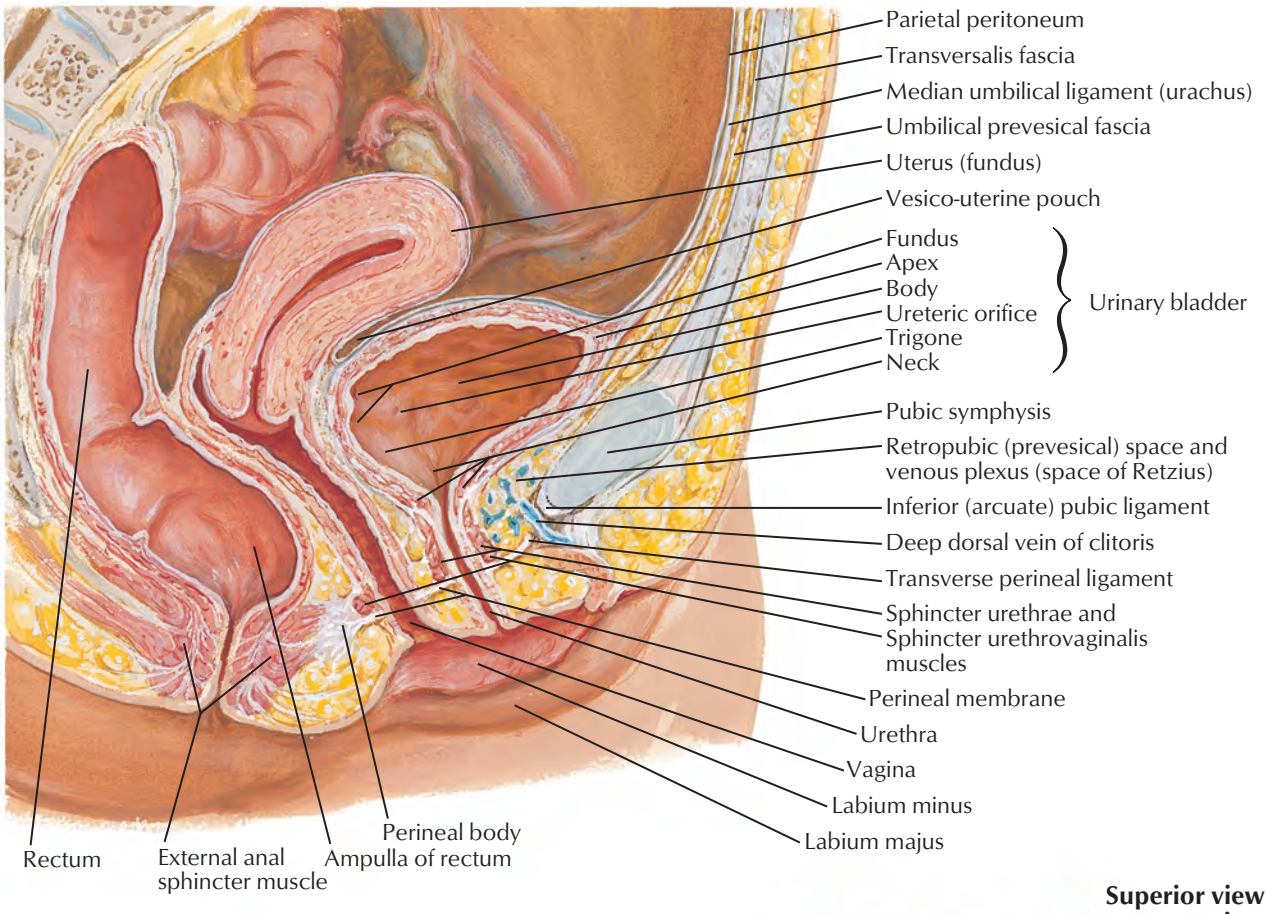



Paramedian (sagittal) dissection
External iliac vessels
Parietal peritoneum
Rectus abdominis muscle
Anterior layer of rectus sheath
Transversalis fascia
Umbilical prevesical fascia
Sub-cutaneous tissue
fatty (Camper's)
membranous (Scarpa's)
Superior pubic ramus (cut)
Fundiform ligament of penis
Suspensory ligament of penis
Areolar tissue and vesical venous plexus in retro-pubic (prevesical) space
Deep dorsal vein of penis
Corpus cavernosum
Deep (Buck's) fascia of penis
Corpus spongiosum
Superficial (dartos) fascia of penis and scrotum
Testis
Ductus (vas) deferens
Urinary bladder and fascia
Ureter (cut)
Seminal vesicle
Rectovesical pouch
Rectum
Rectoprostatic (Denonvilliers') fascia
Prostate (covered by fascia)
Ischiopubic ramus (cut)
Pelvic diaphragm (levator ani muscle)
Deep transverse perineal muscle
Perineal body
Deep
Superficial
Subcutaneous
External anal sphincter muscle
Deep perineal (investing or Gallaudet's) fascia
Superficial perineal (Colles') fascia (inferior fascia of superficial perineal space)
Superficial (dartos) fascia of scrotum
External spermatic fascia
Median (sagittal) section
Urachus
Urinary bladder
Apex
Fundus
Body
Trigone
Neck
Pubic symphysis
Suspensory ligament of penis
Inferior (arcuate) pubic ligament
Prostatic venous plexus
Transverse perineal ligament (anterior thickening of perineal membrane)
Perineal membrane
Superficial perineal space
Corpus cavernosum
Corpus spongiosum
Superficial (dartos) fascia of penis and scrotum
Deep (Buck's) fascia of penis
Prepuce
Glans penis and external urethral meatus
Vesical fascia
Rectovesical pouch
Rectum
Seminal vesicle
Prostate
Rectoprostatic (Denonvilliers') fascia
External urethral sphincter muscle
Bulbo-urethral (Cowper's) gland
Perineal body
Bulbospongiosus muscle
Deep perineal (investing or Gallaudet's) fascia
Superficial perineal (Colles') fascia
Deep (Buck's) fascia of penis
Septum of scrotum
Navicular fossa

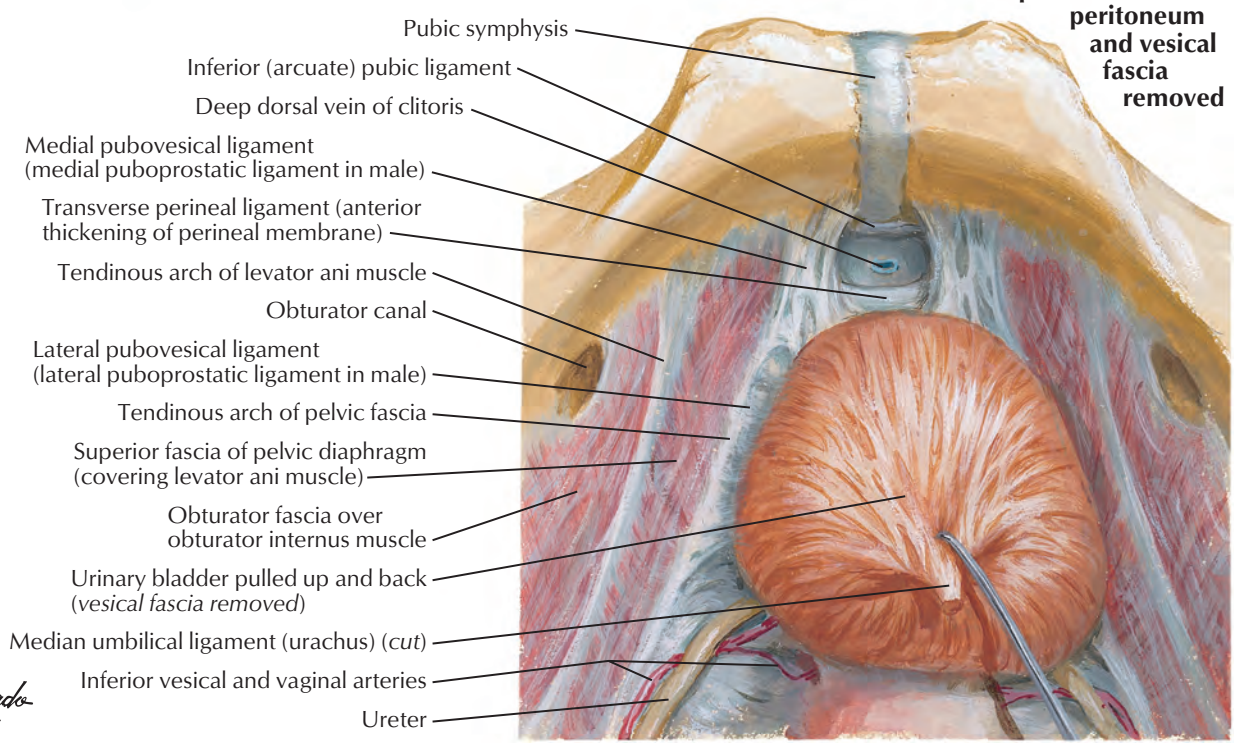
Superior view

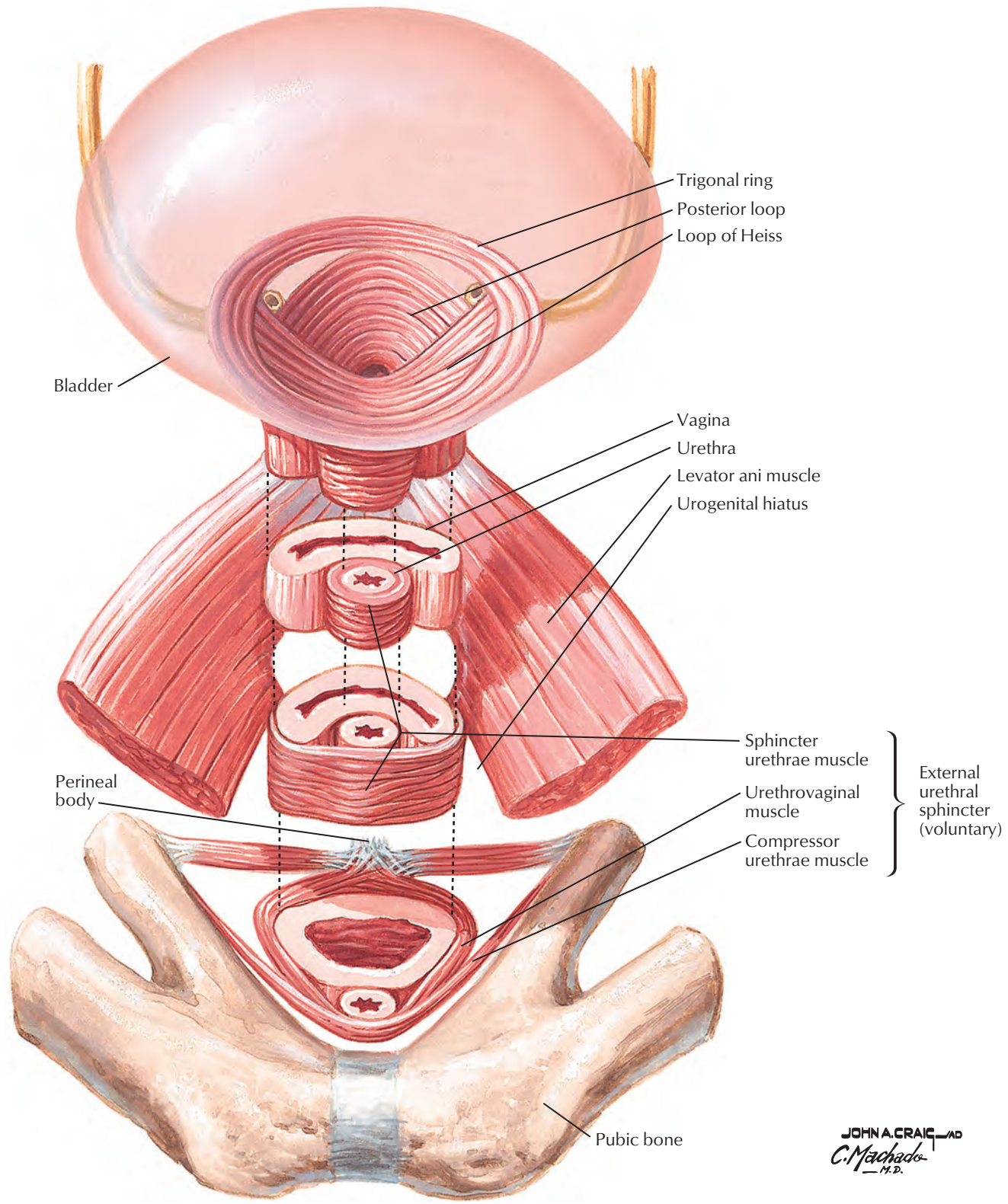


Female: midsagittal section



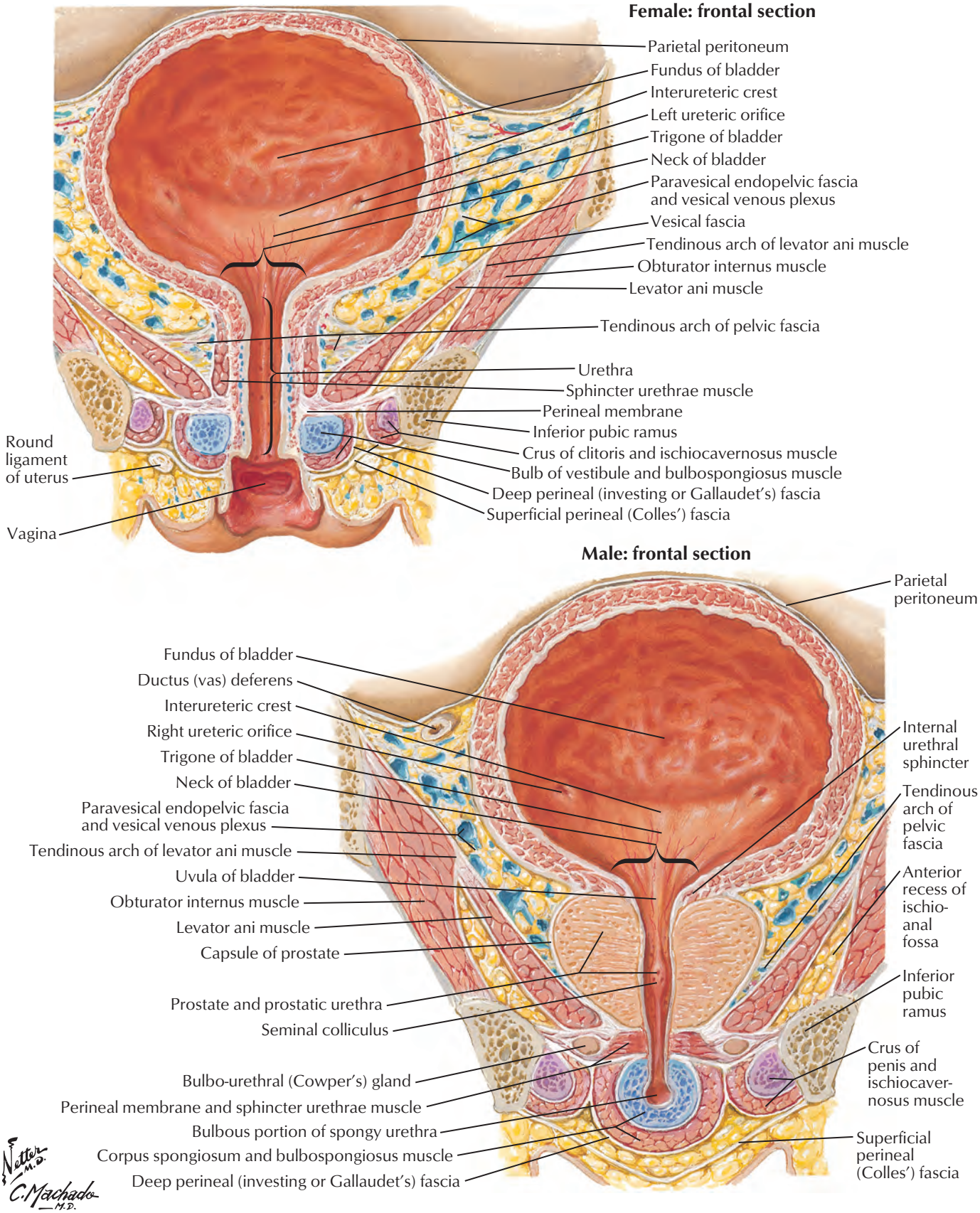
Superior view with peritoneum and vesical fascia removed

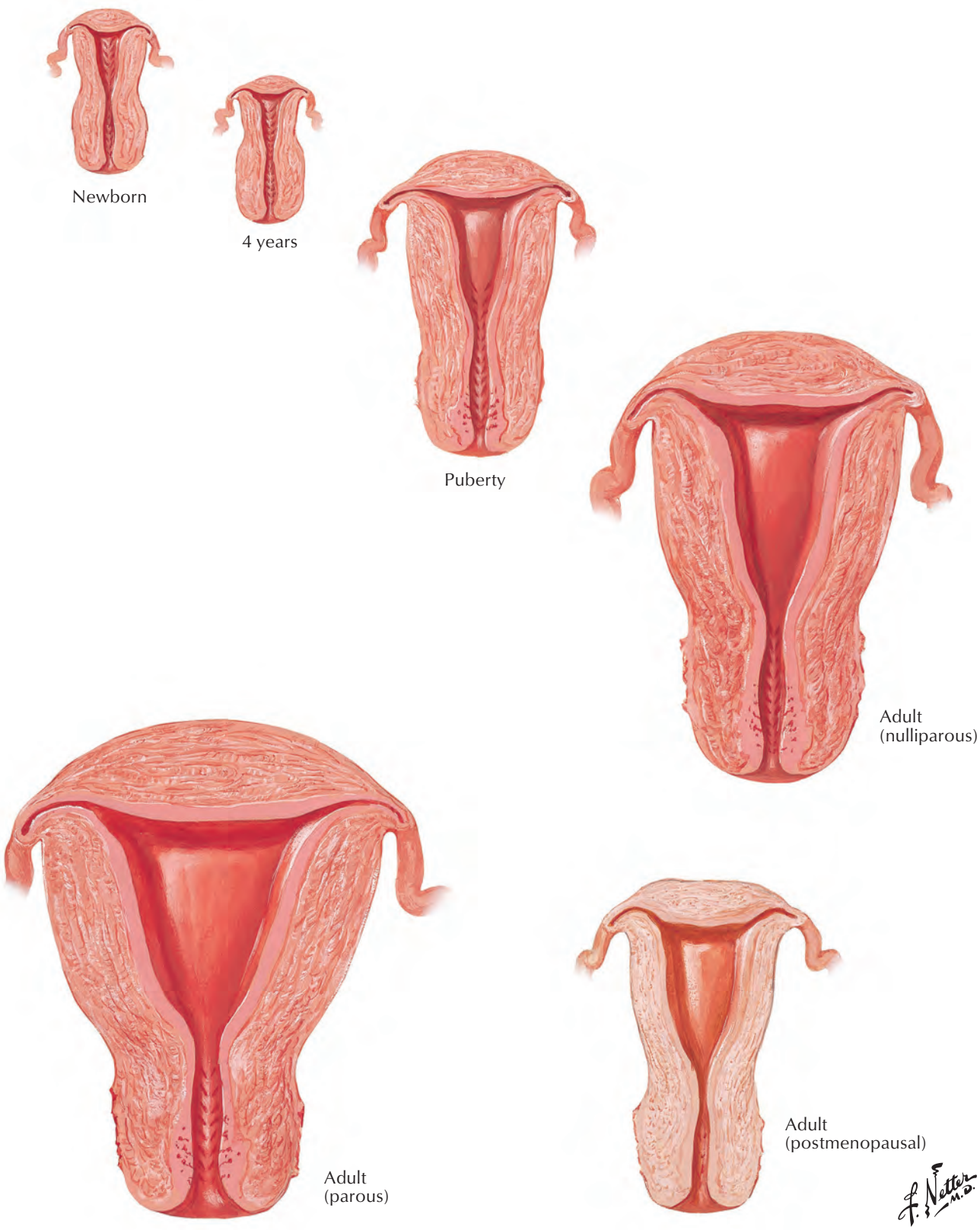



Trigonal ring
Posterior loop
Loop of Heiss
Bladder
Vagina
Urethra
Levator ani muscle
Urogenital hiatus
Sphincter urethrae muscle
Perineal body
Urethrovaginal muscle
Compressor urethrae muscle
External urethral sphincter (voluntary)
Pubic bone
JOHN A. CRAIG M.D.
C. Machado M.D.

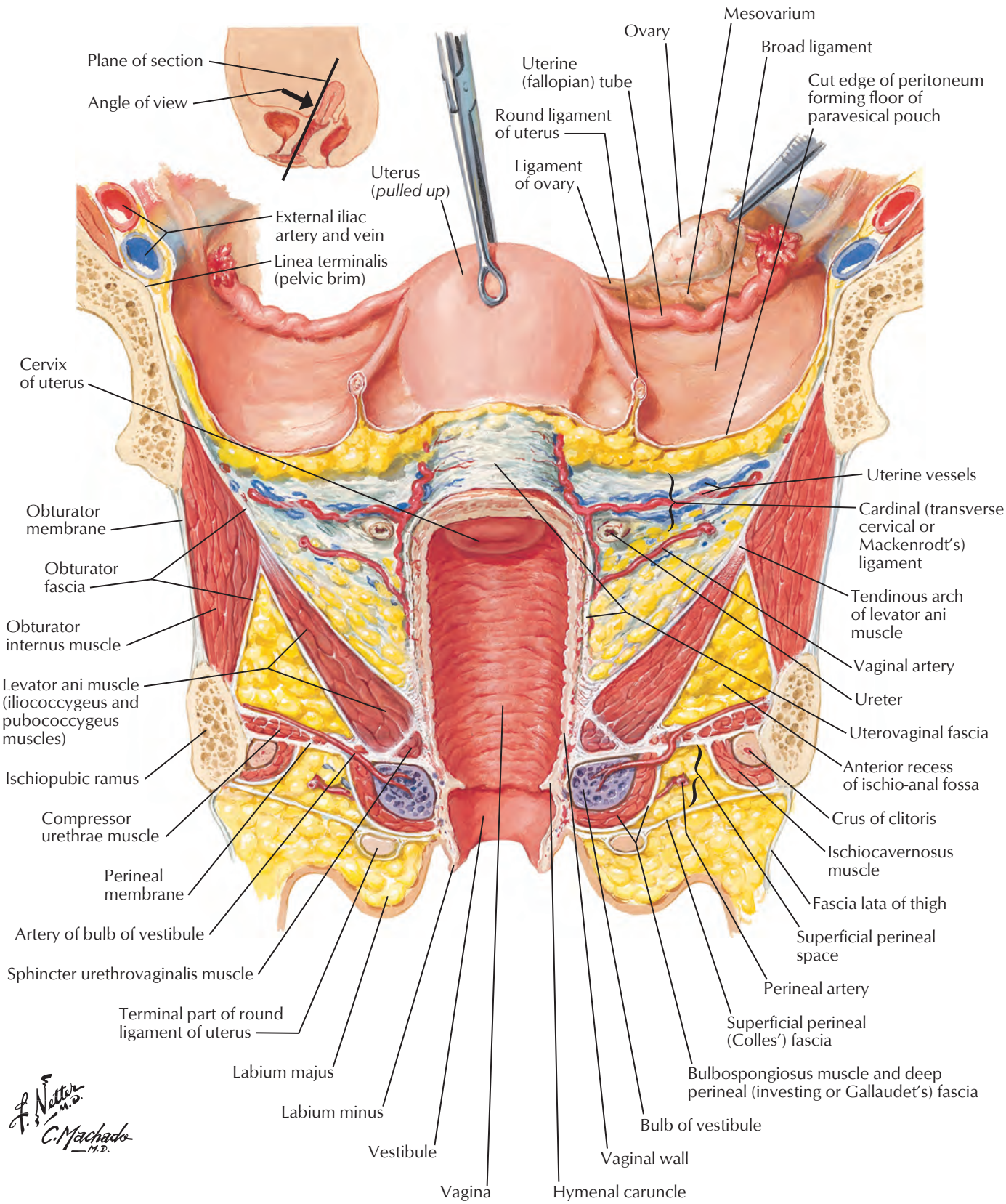
Urinary Bladder: Female and Male

See also **Plates 340, 344, 381**

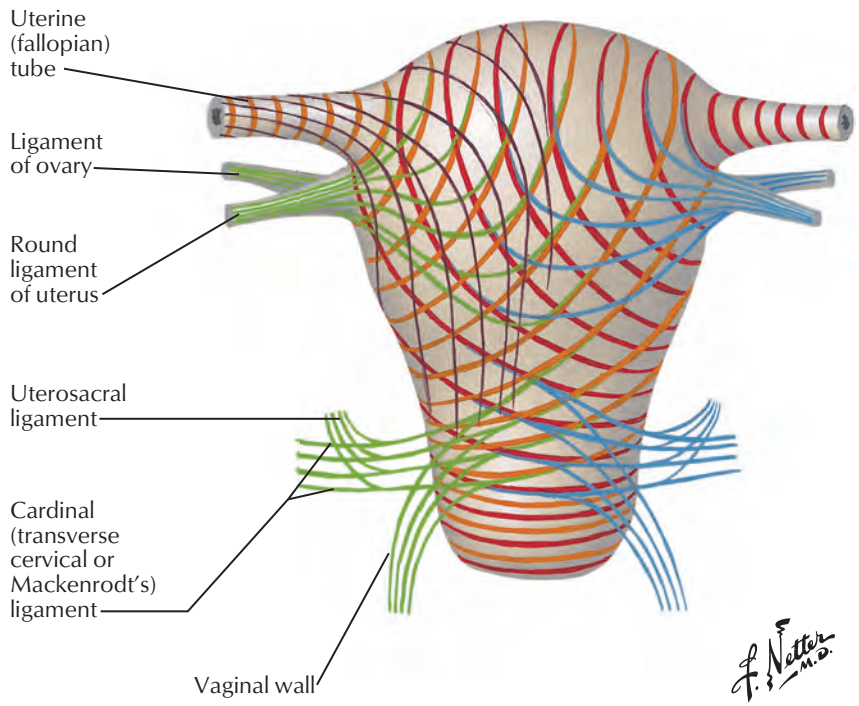



Newborn
4 years
Puberty
Adult
(nulliparous)
Adult
(parous)
Adult
(postmenopausal)
F. Netter M.D.

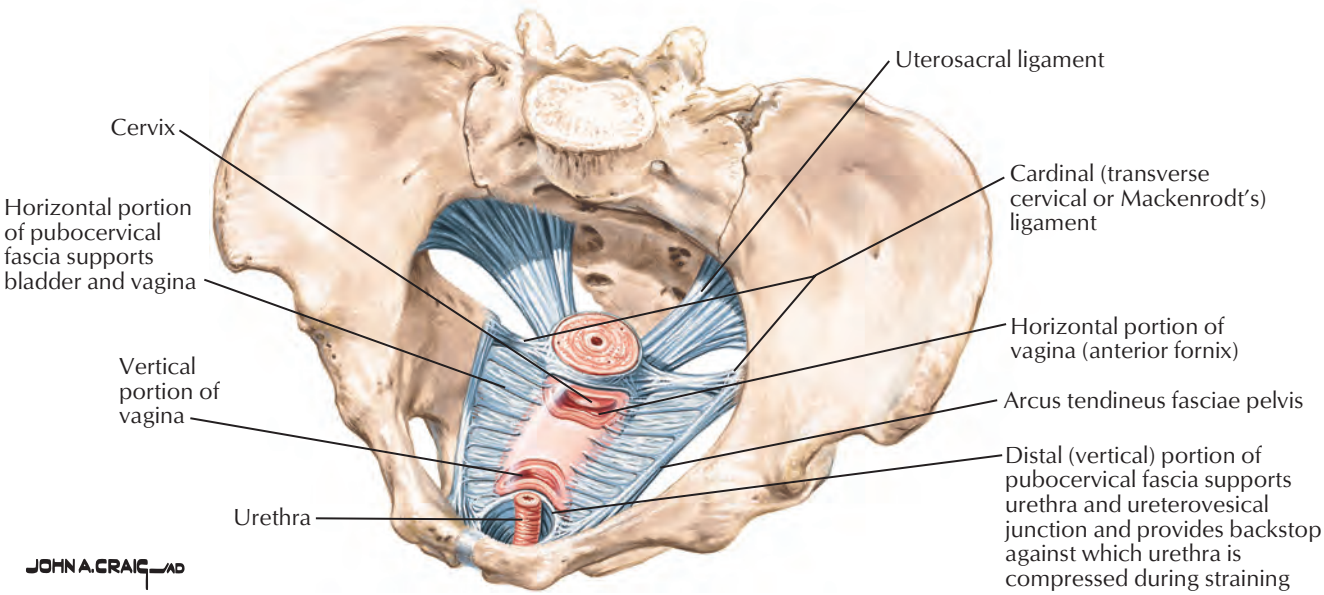
See also **Plates 382, 384, 390**

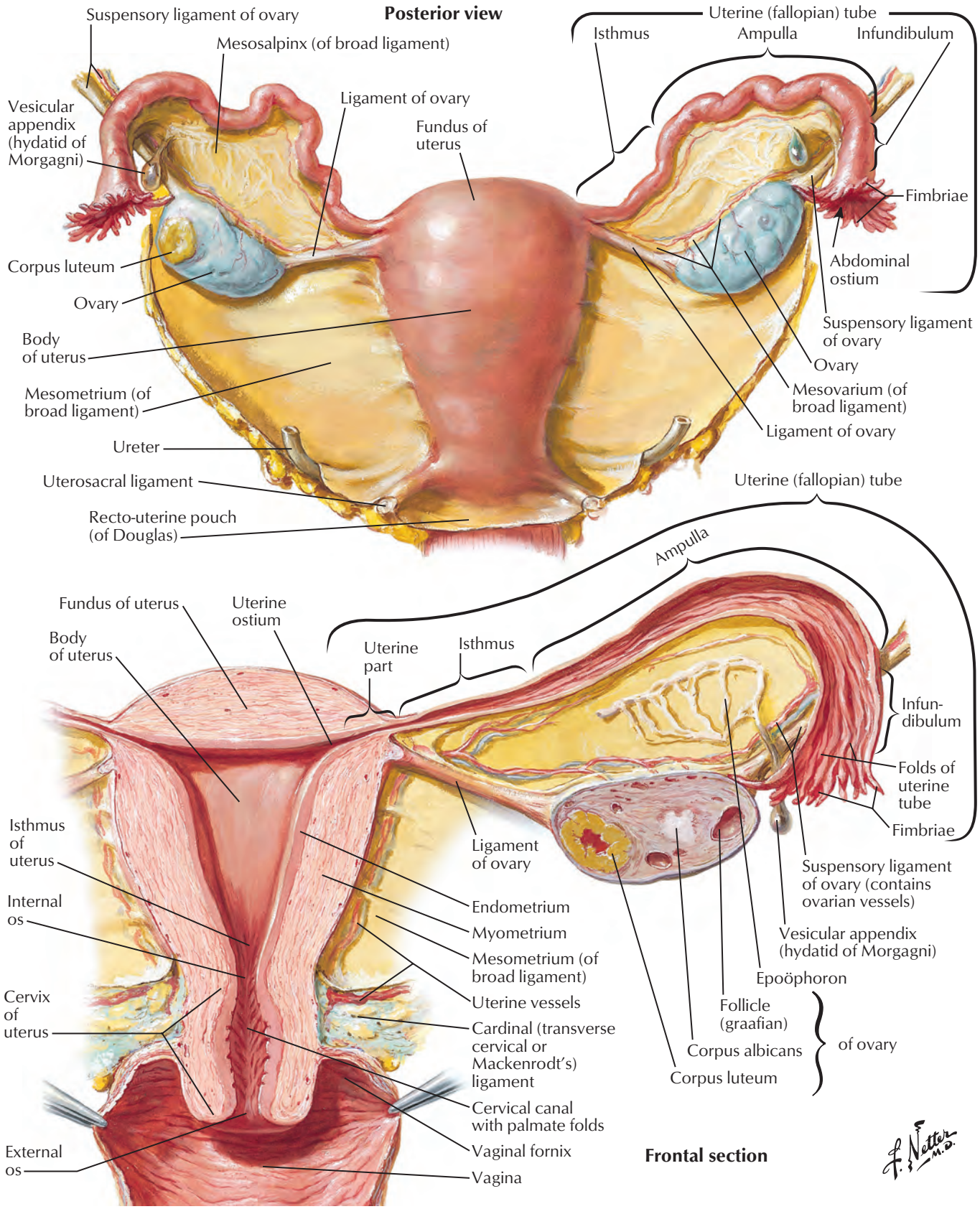


Fascial ligaments of uterus

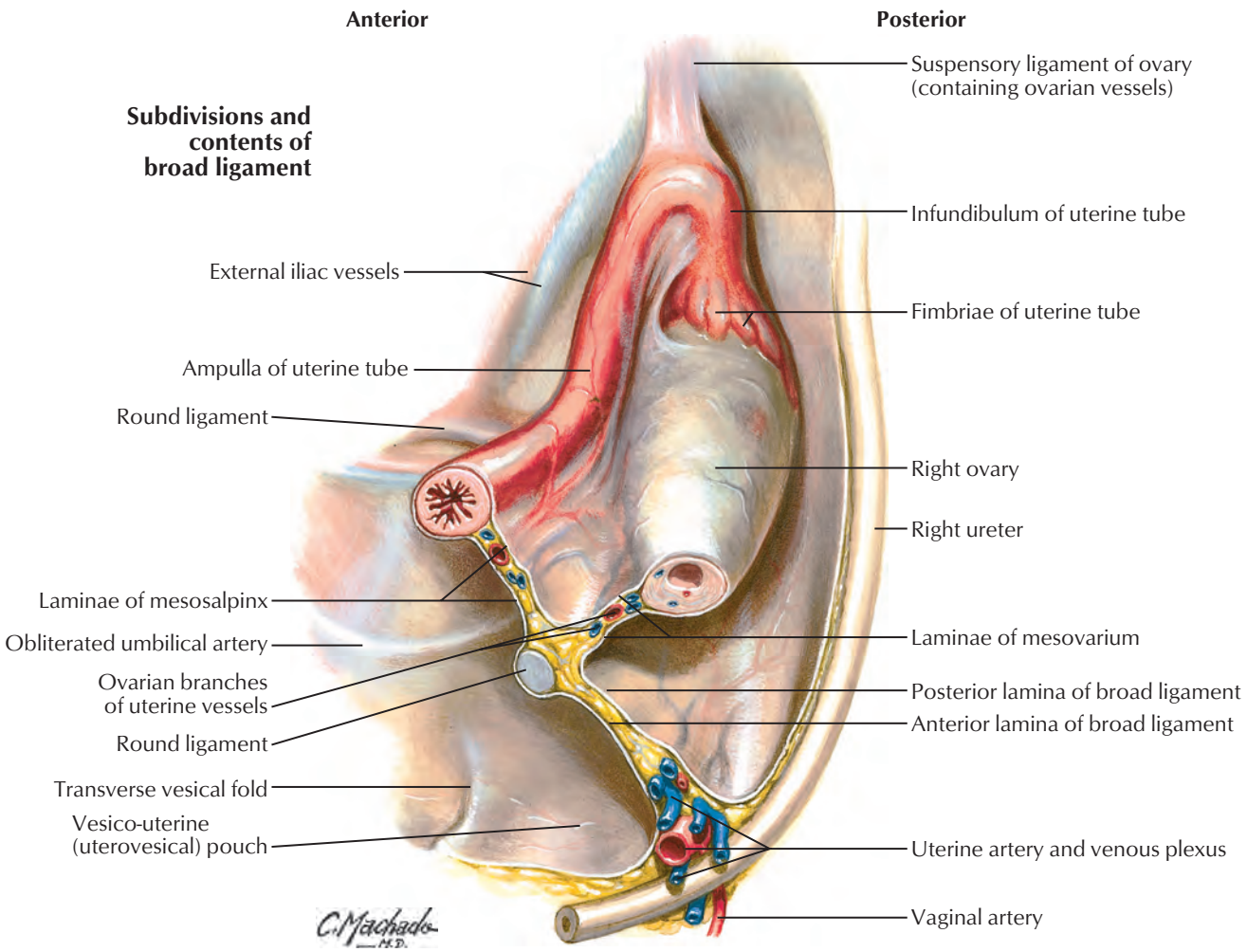


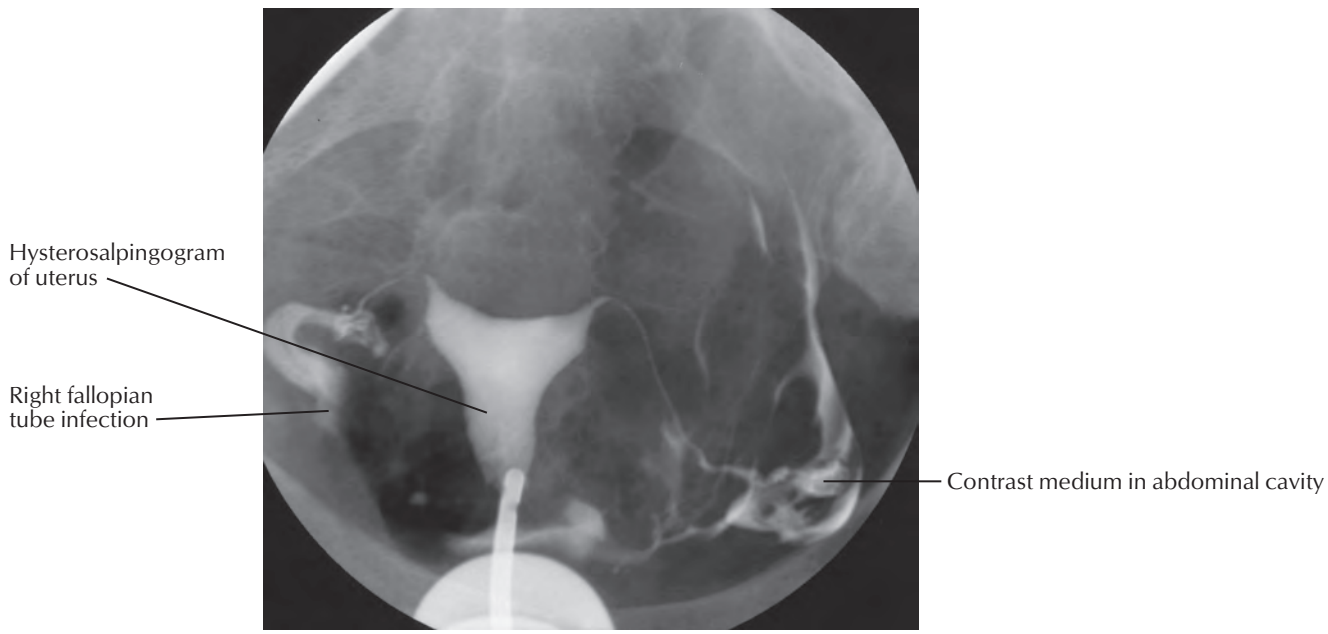
Pelvic fascia and ligaments




Posterior view
Suspensory ligament of ovary
Mesosalpinx (of broad ligament)
Vesicular appendix (hydatid of Morgagni)
Ligament of ovary
Fundus of uterus
Corpus luteum
Ovary
Body of uterus
Mesometrium (of broad ligament)
Ureter
Uterosacral ligament
Recto-uterine pouch (of Douglas)
Uterine (fallopian) tube
Isthmus
Ampulla
Infundibulum
Fimbriae
Abdominal ostium
Suspensory ligament of ovary
Ovary
Mesovarium (of broad ligament)
Ligament of ovary
Uterine (fallopian) tube
Ampulla
Fundus of uterus
Uterine ostium
Body of uterus
Uterine part
Isthmus
Infun-dibulum
Folds of uterine tube
Fimbriae
Isthmus of uterus
Internal os
Cervix of uterus
External os
Ligament of ovary
Endometrium
Myometrium
Mesometrium (of broad ligament)
Uterine vessels
Cardinal (transverse cervical or Mackenrodt's) ligament
Cervical canal with palmate folds
Vaginal fornix
Vagina
Suspensory ligament of ovary (contains ovarian vessels)
Vesicular appendix (hydatid of Morgagni)
Epoöphoron
Follicle (graafian)
Corpus albicans
Corpus luteum
of ovary
Frontal section

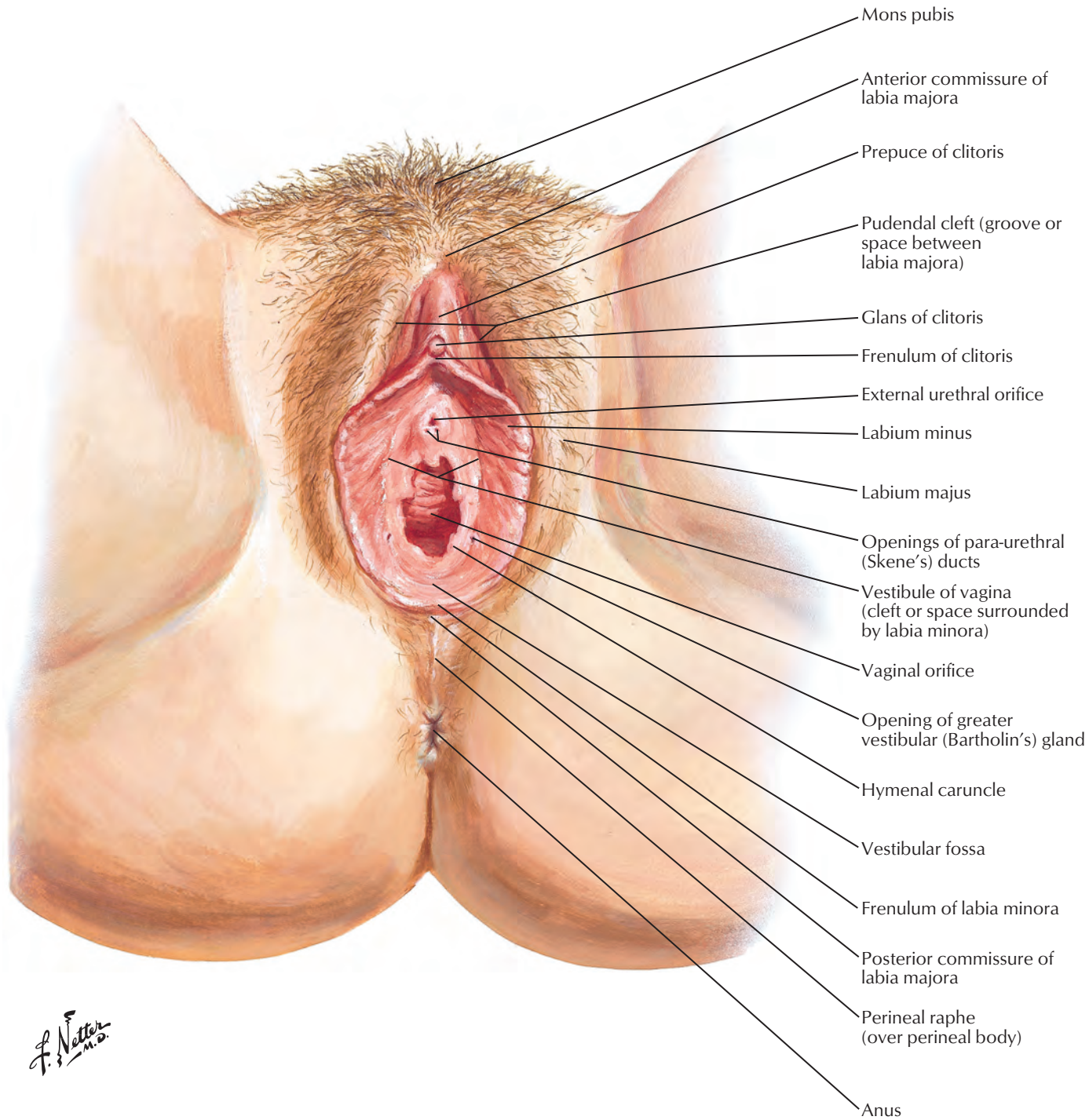
Subdivisions and contents of broad ligament

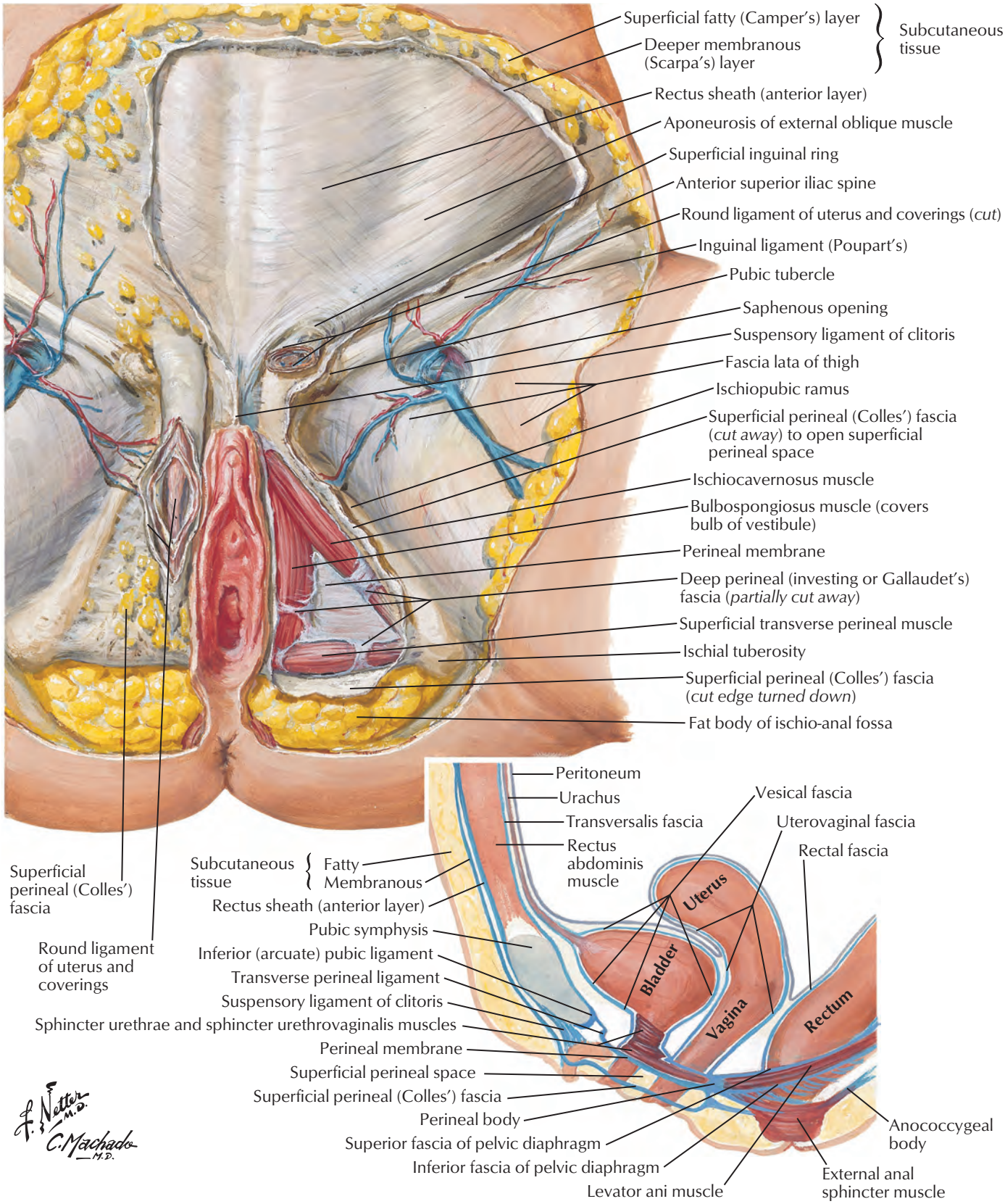


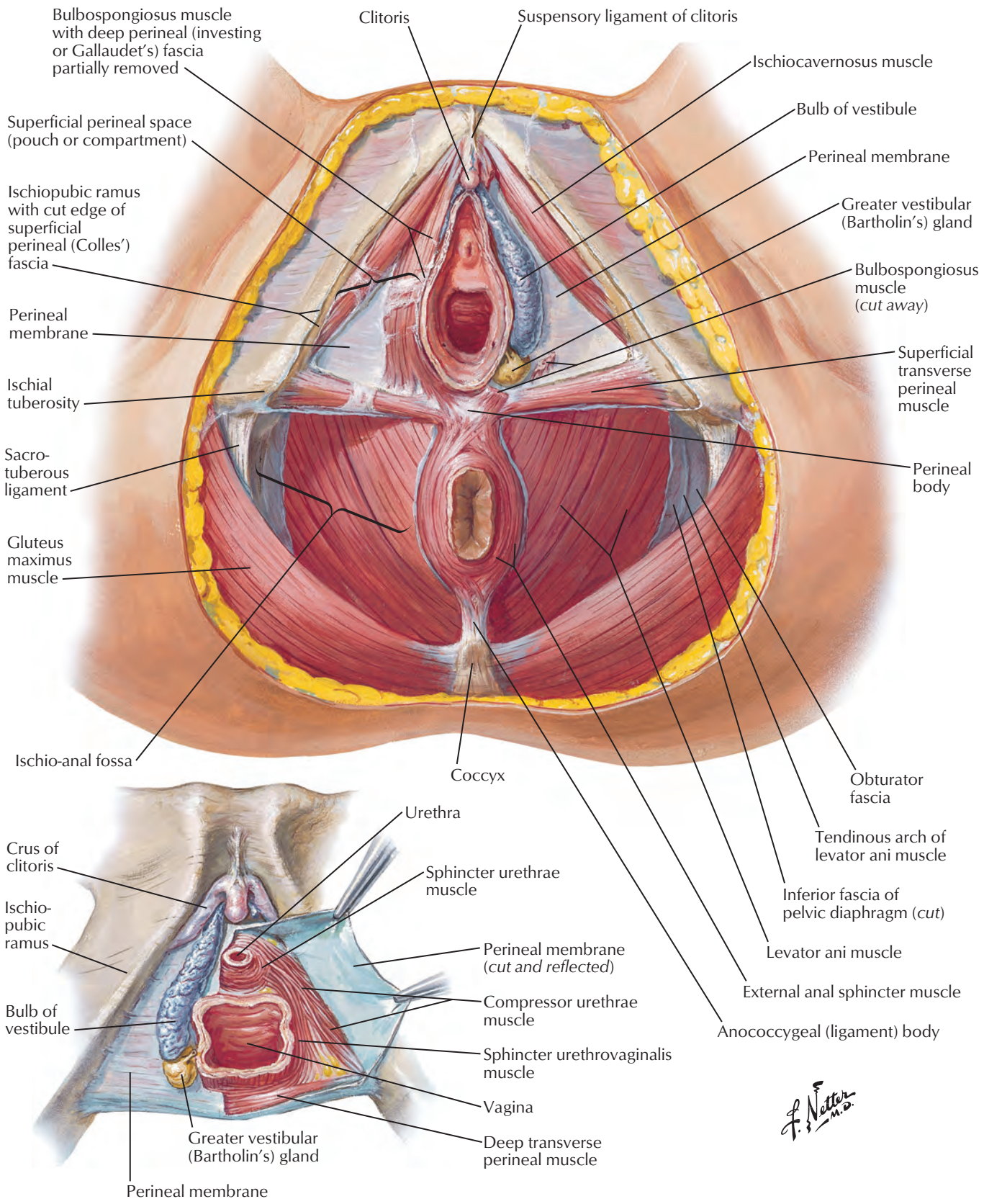


Female Perineum and External Genitalia (Pudendum or Vulva)

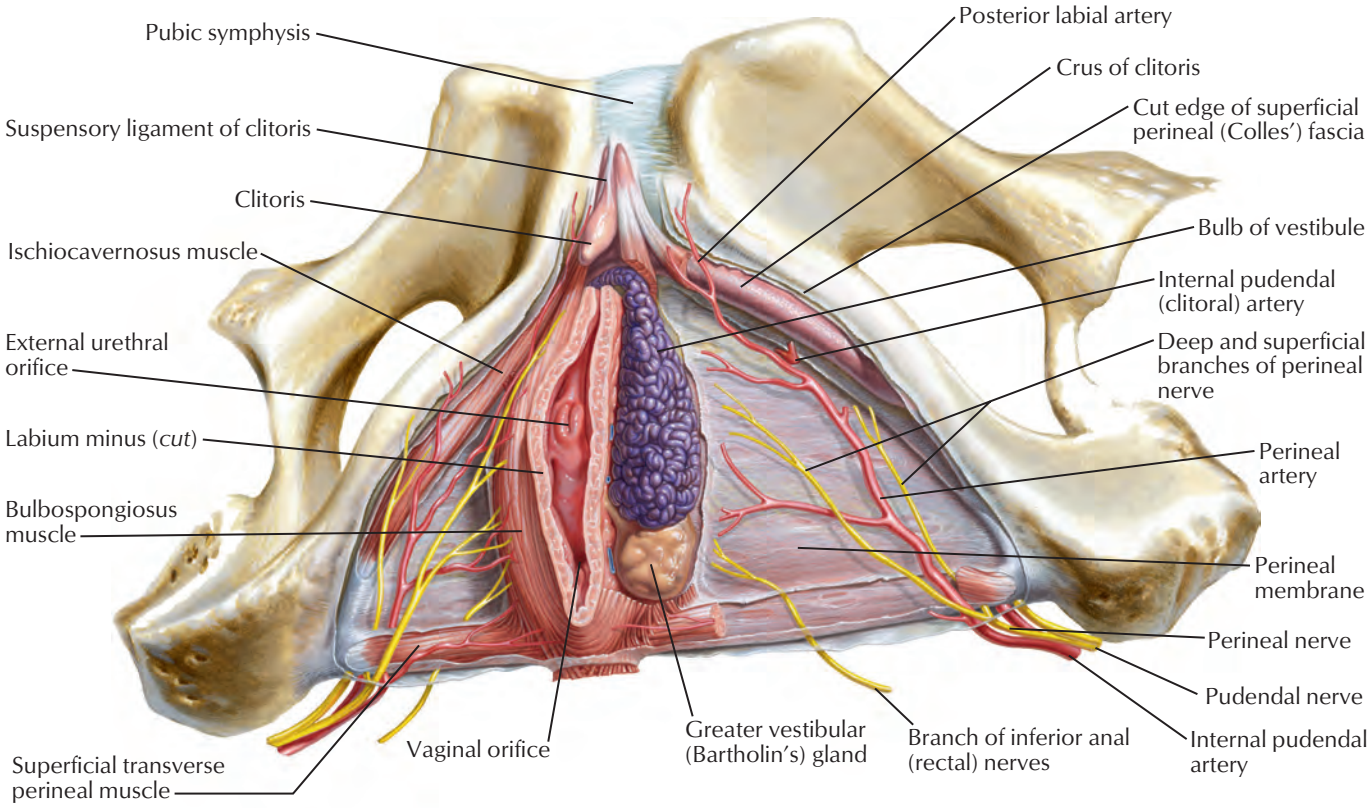
See also **Plates 382, 385, 391**



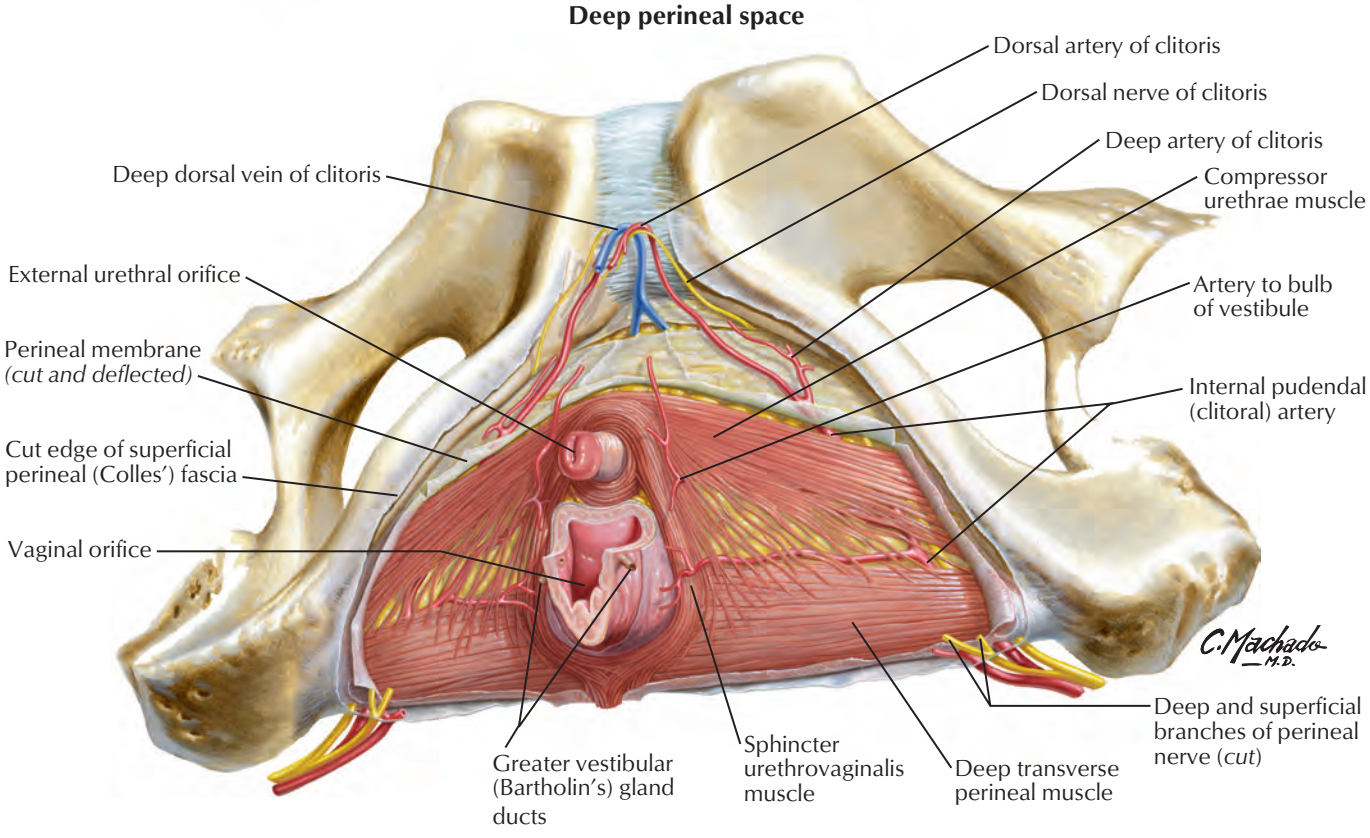

Superficial fatty (Camper's) layer
Deeper membranous (Scarpa's) layer
Subcutaneous tissue
Rectus sheath (anterior layer)
Aponeurosis of external oblique muscle
Superficial inguinal ring
Anterior superior iliac spine
Round ligament of uterus and coverings (cut)
Inguinal ligament (Poupart's)
Pubic tubercle
Saphenous opening
Suspensory ligament of clitoris
Fascia lata of thigh
Ischiopubic ramus
Superficial perineal (Colles') fascia (cut away) to open superficial perineal space
Ischiocavernosus muscle
Bulbospongiosus muscle (covers bulb of vestibule)
Perineal membrane
Deep perineal (investing or Gallaudet's) fascia (partially cut away)
Superficial transverse perineal muscle
Ischial tuberosity
Superficial perineal (Colles') fascia (cut edge turned down)
Fat body of ischio-anal fossa
Peritoneum
Urachus
Transversalis fascia
Rectus abdominis muscle
Vesical fascia
Uterovaginal fascia
Rectal fascia
Uterus
Bladder
Vagina
Rectum
Superficial perineal (Colles') fascia
Subcutaneous tissue
Fatty
Membranous
Rectus sheath (anterior layer)
Pubic symphysis
Inferior (arcuate) pubic ligament
Transverse perineal ligament
Suspensory ligament of clitoris
Sphincter urethrae and sphincter urethrovaginalis muscles
Perineal membrane
Superficial perineal space
Superficial perineal (Colles') fascia
Perineal body
Superior fascia of pelvic diaphragm
Inferior fascia of pelvic diaphragm
Levator ani muscle
Round ligament of uterus and coverings
Anococcygeal body
External anal sphincter muscle
F. Netter M.D.
C. Machado M.D.

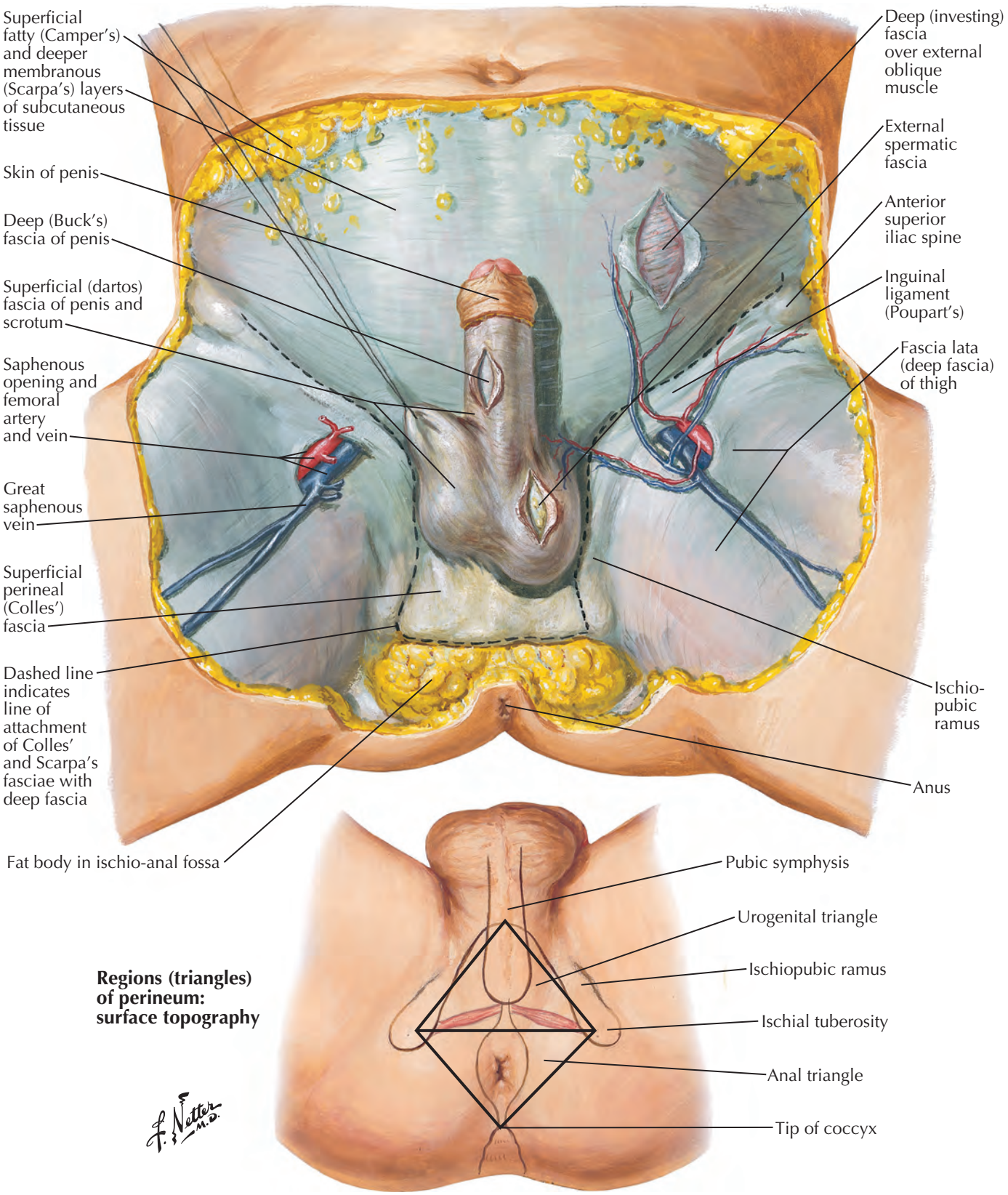

Bulbospongiosus muscle with deep perineal (investing or Gallaudet's) fascia partially removed
Clitoris
Suspensory ligament of clitoris
Ischiocavernosus muscle
Bulb of vestibule
Superficial perineal space (pouch or compartment)
Perineal membrane
Ischiopubic ramus with cut edge of superficial perineal (Colles') fascia
Greater vestibular (Bartholin's) gland
Bulbospongiosus muscle (*cut away*)
Perineal membrane
Superficial transverse perineal muscle
Ischial tuberosity
Sacro-tuberous ligament
Perineal body
Gluteus maximus muscle
Ischio-anal fossa
Coccyx
Obturator fascia
Tendinous arch of levator ani muscle
Inferior fascia of pelvic diaphragm (*cut*)
Levator ani muscle
External anal sphincter muscle
Anococcygeal (ligament) body
Urethra
Crus of clitoris
Sphincter urethrae muscle
Ischio-pubic ramus
Perineal membrane (*cut and reflected*)
Compressor urethrae muscle
Bulb of vestibule
Sphincter urethrovaginalis muscle
Vagina
Greater vestibular (Bartholin's) gland
Deep transverse perineal muscle
Perineal membrane

Superficial perineal space

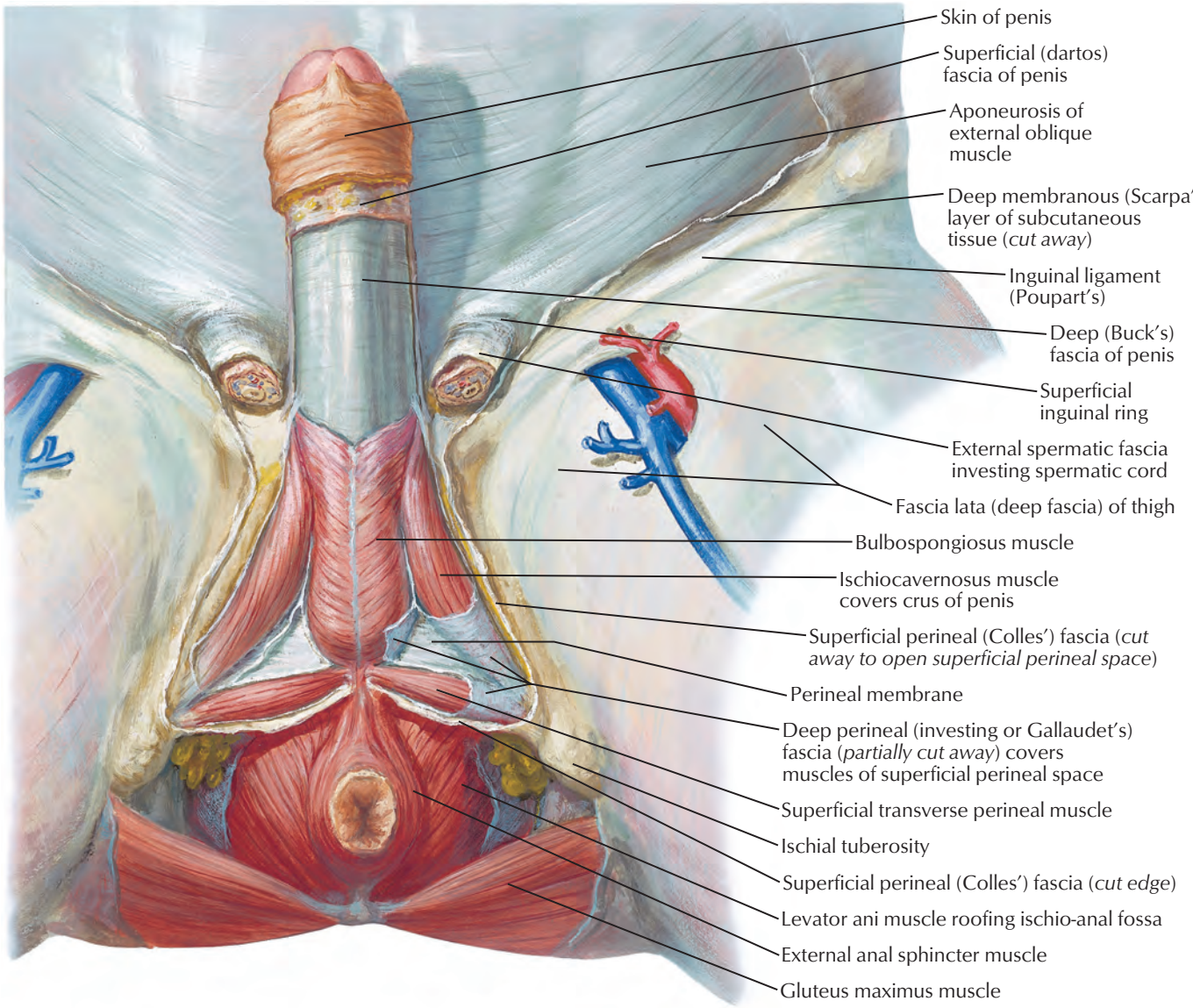


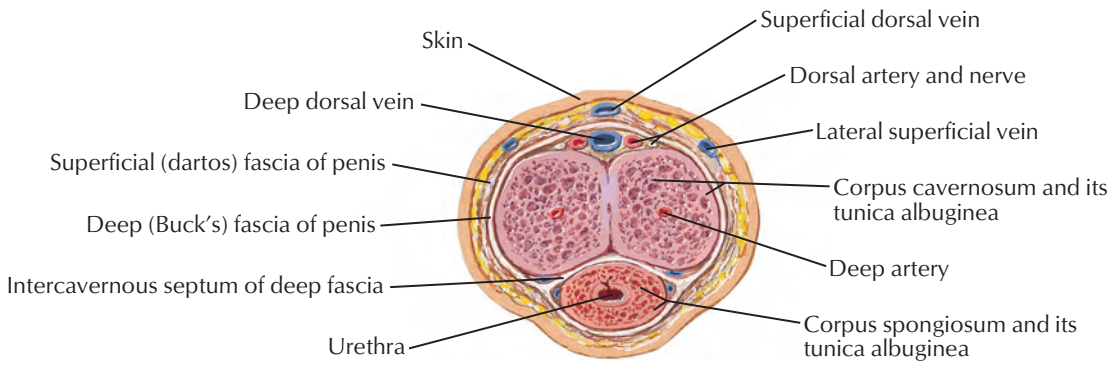
Deep perineal space



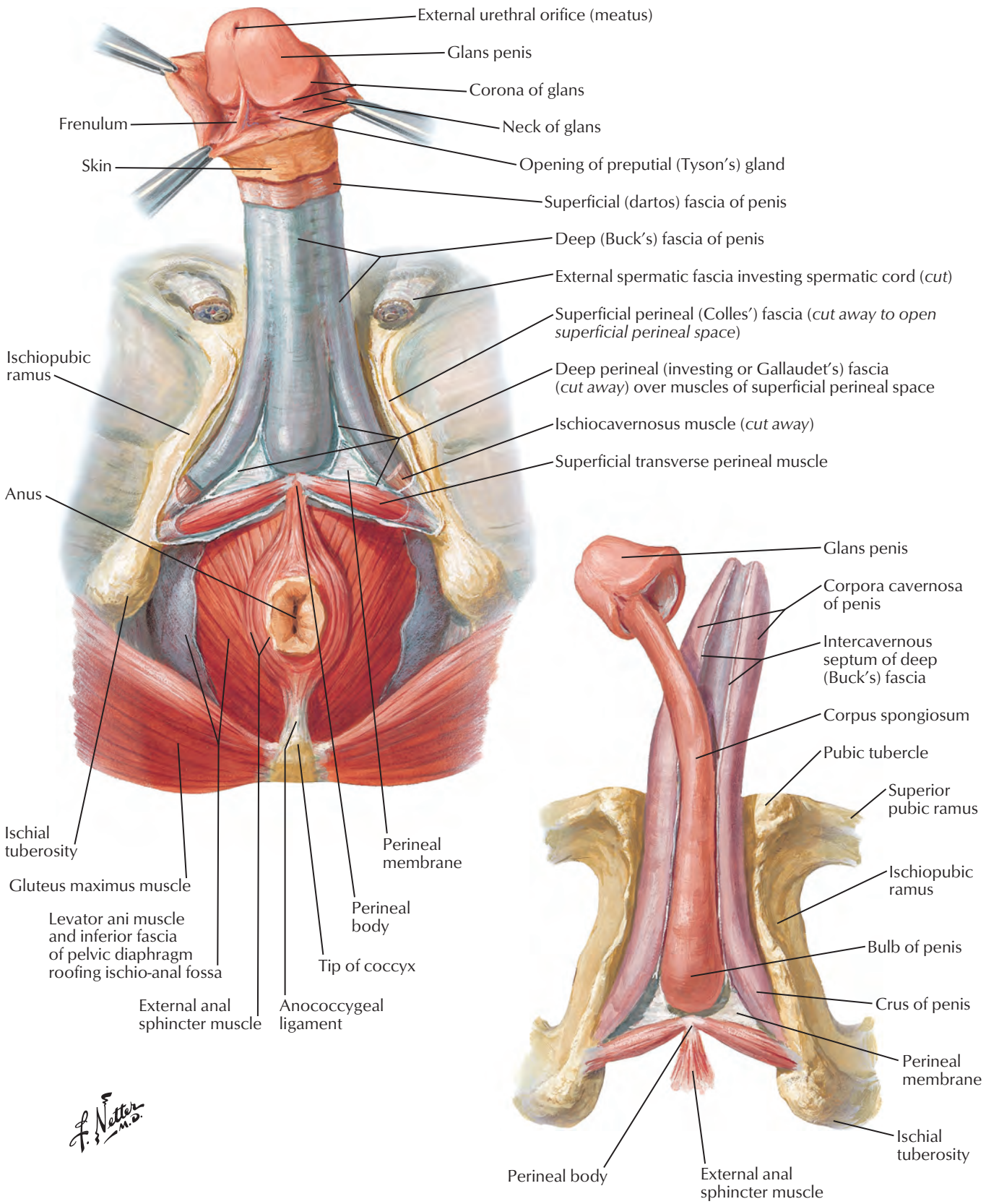


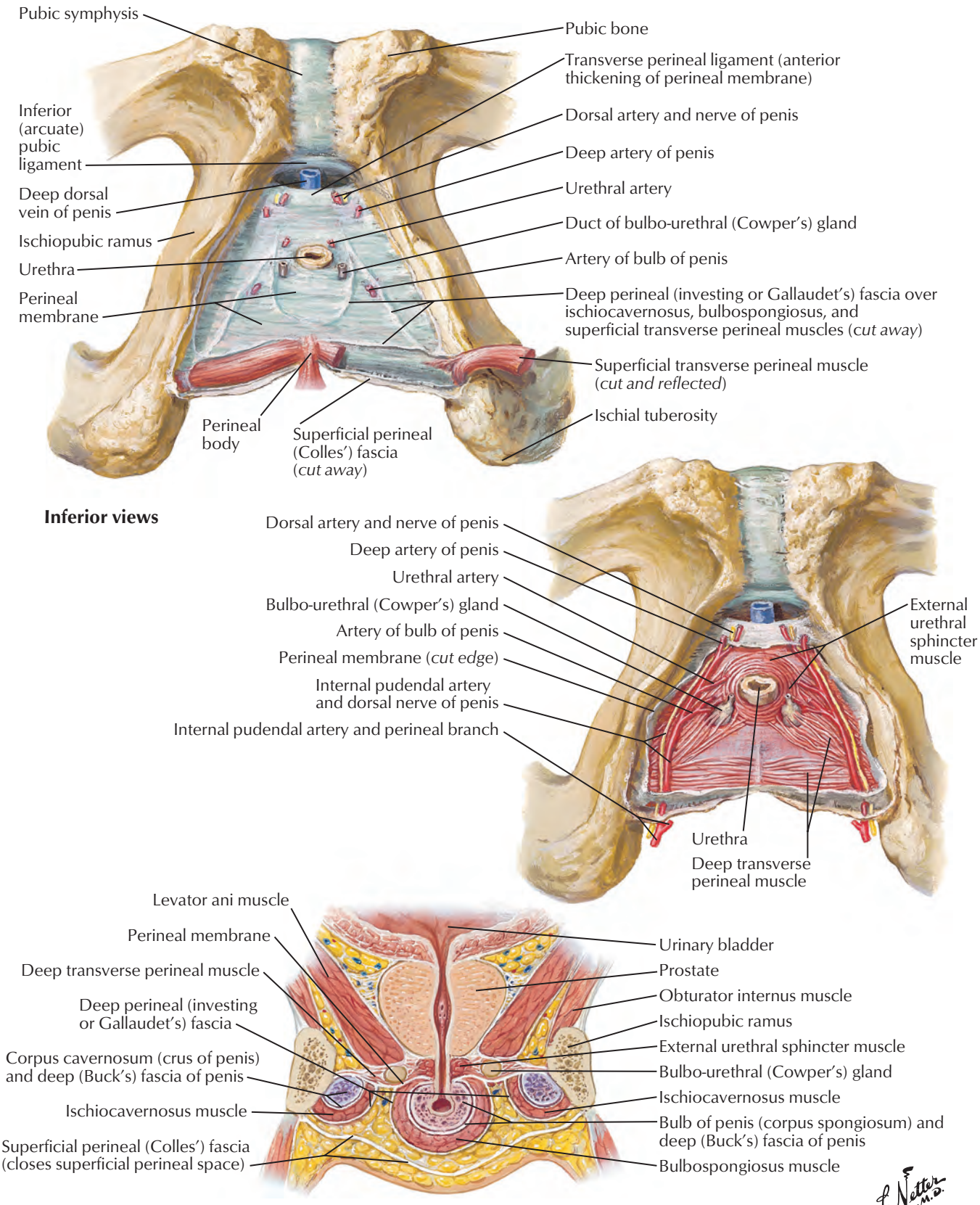
Regions (triangles) of perineum: surface topography





Transverse section through body of penis

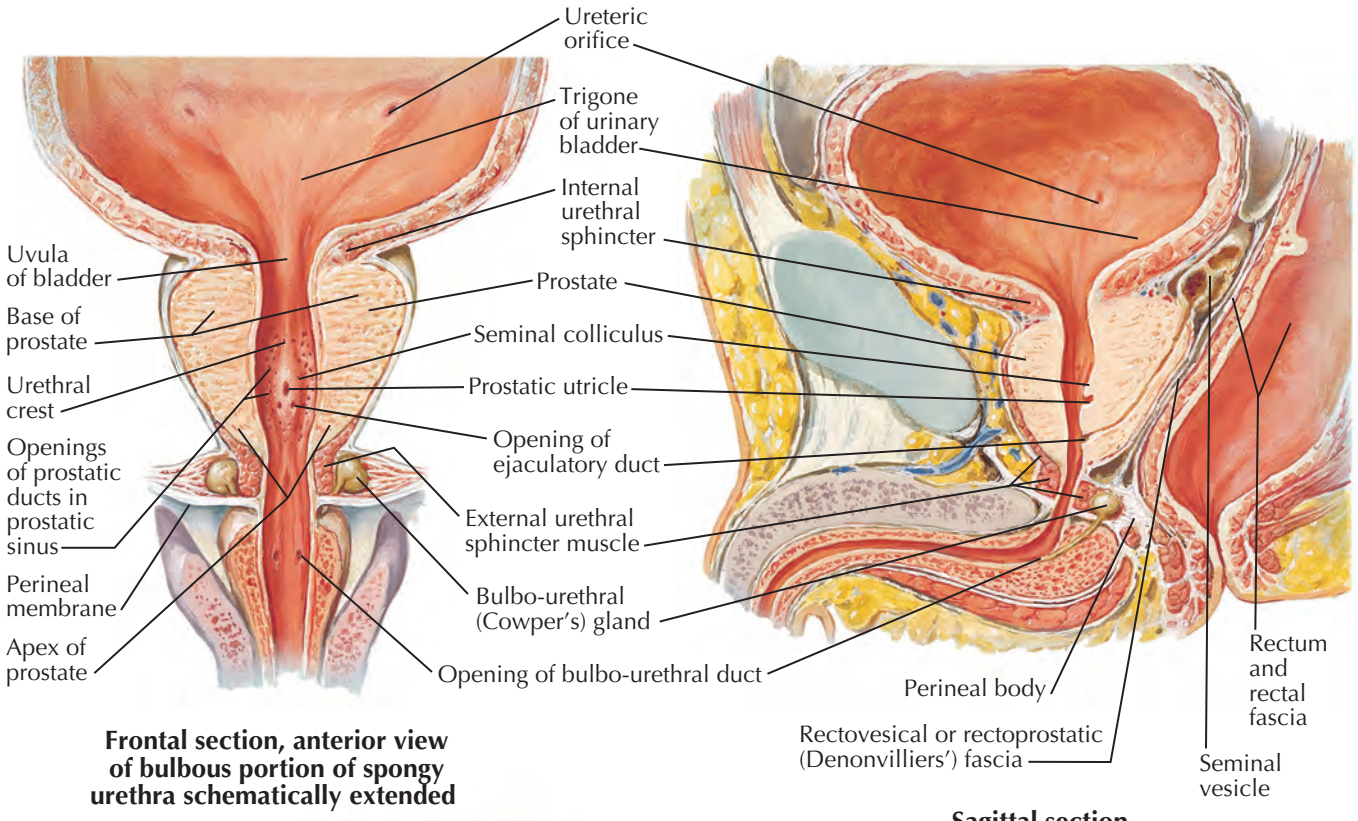

External urethral orifice (meatus)
Glans penis
Corona of glans
Frenulum
Neck of glans
Skin
Opening of preputial (Tyson's) gland
Superficial (dartos) fascia of penis
Deep (Buck's) fascia of penis
External spermatic fascia investing spermatic cord (cut)
Superficial perineal (Colles') fascia (cut away to open superficial perineal space)
Ischiopubic ramus
Deep perineal (investing or Gallaudet's) fascia (cut away) over muscles of superficial perineal space
Ischiocavernosus muscle (cut away)
Superficial transverse perineal muscle
Anus
Ischial tuberosity
Perineal membrane
Gluteus maximus muscle
Perineal body
Levator ani muscle and inferior fascia of pelvic diaphragm roofing ischio-anal fossa
Tip of coccyx
External anal sphincter muscle
Anococcygeal ligament
Glans penis
Corpora cavernosa of penis
Intercavernous septum of deep (Buck's) fascia
Corpus spongiosum
Pubic tubercle
Superior pubic ramus
Ischiopubic ramus
Bulb of penis
Crus of penis
Perineal membrane
Ischial tuberosity
Perineal body
External anal sphincter muscle



Frontal section, anterior view of perineum: schema

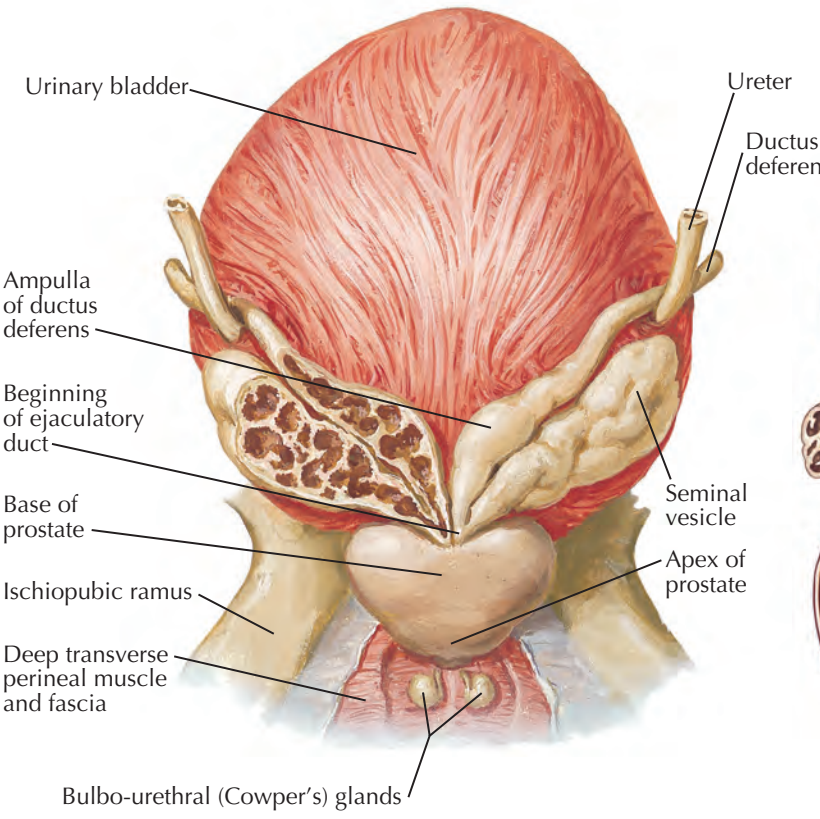
Prostate and Seminal Vesicles

See also **Plates 344, 348, 381**

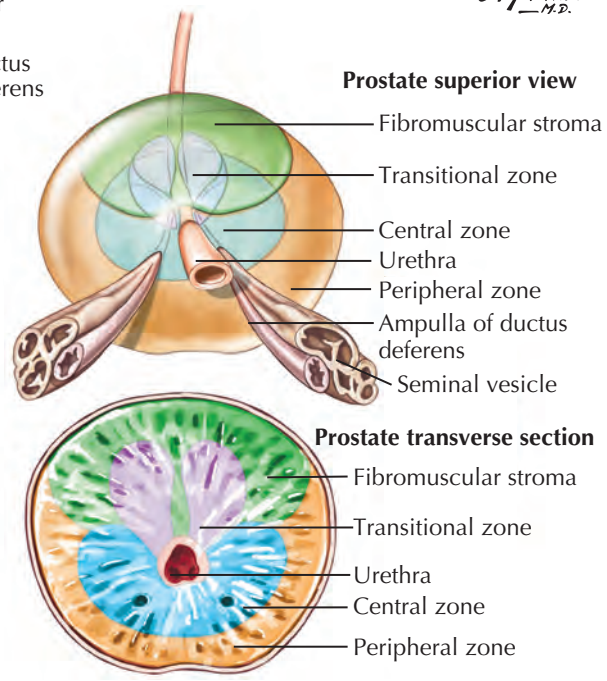


Frontal section, anterior view of bulbous portion of spongy urethra schematically extended

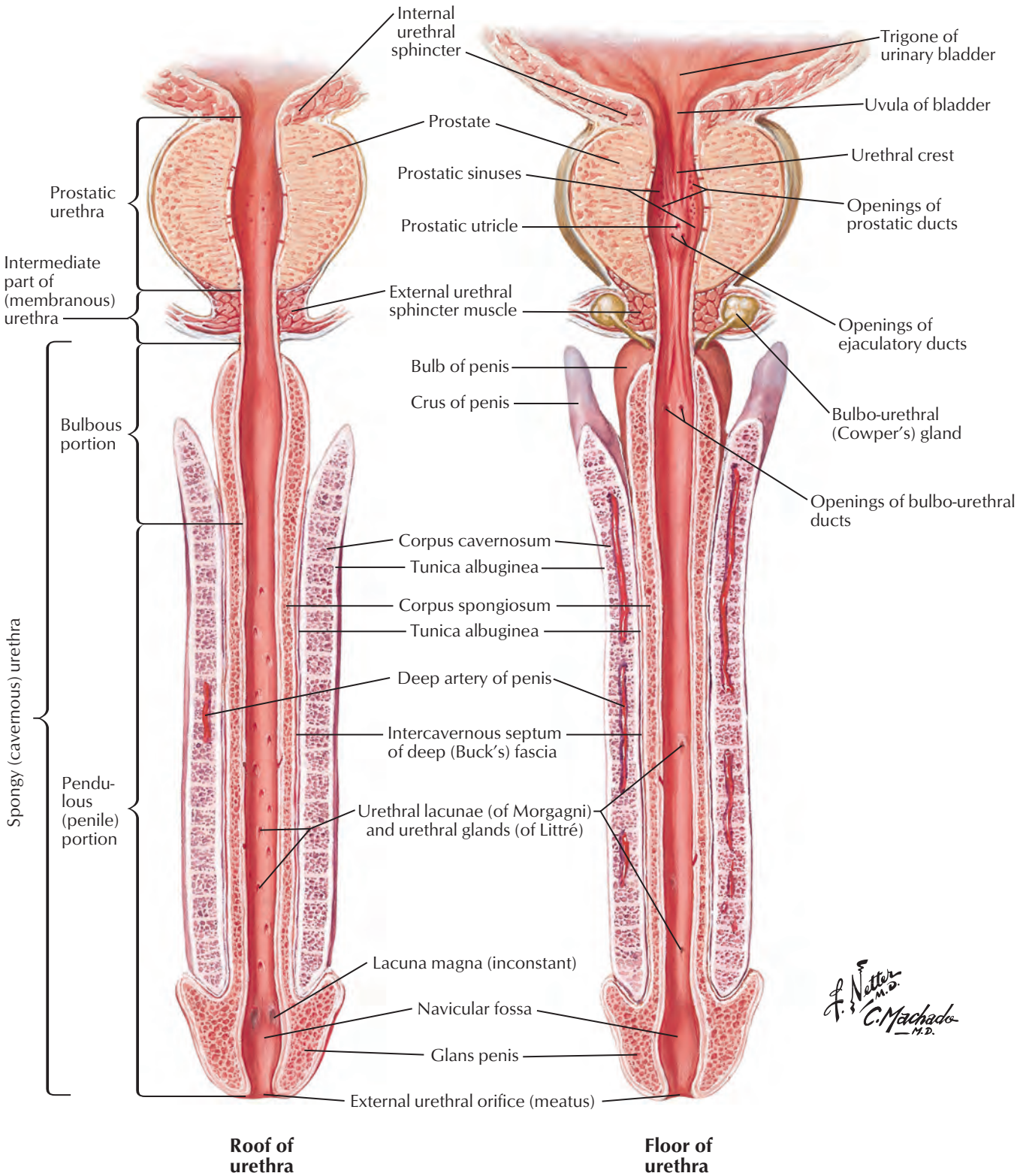
Sagittal section

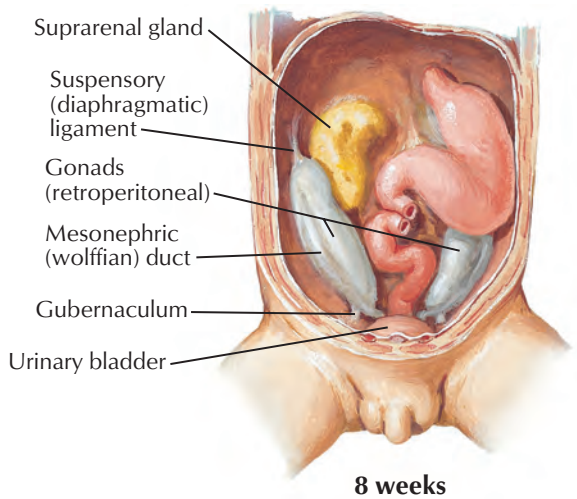


Posterior view

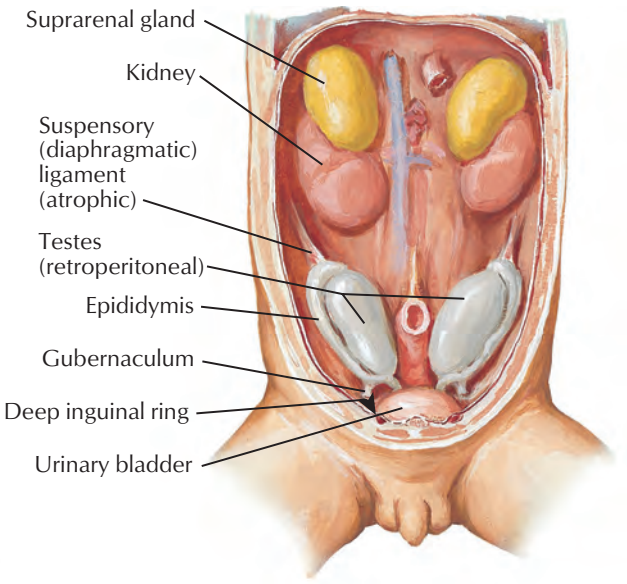


Posterior view

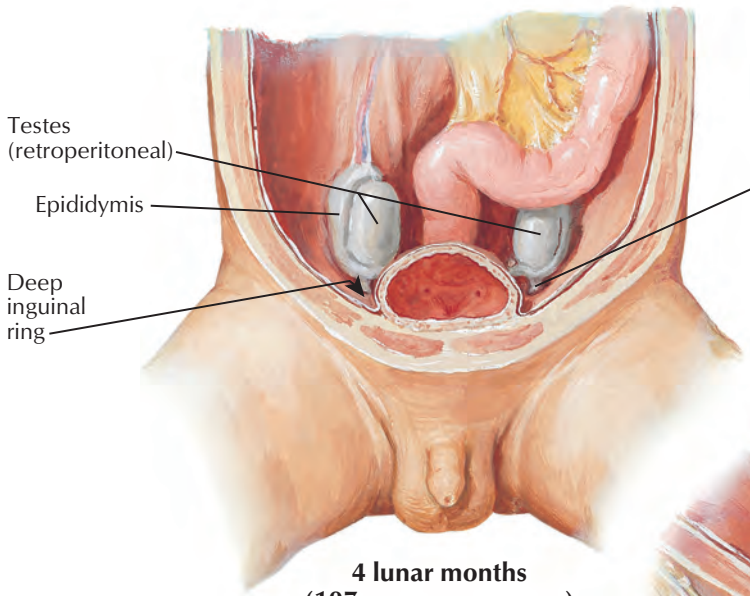

Internal urethral sphincter
Prostate
Prostatic sinuses
Prostatic utricle
External urethral sphincter muscle
Bulb of penis
Crus of penis
Corpus cavernosum
Tunica albuginea
Corpus spongiosum
Tunica albuginea
Deep artery of penis
Intercavernous septum of deep (Buck's) fascia
Urethral lacunae (of Morgagni) and urethral glands (of Littré)
Lacuna magna (inconstant)
Navicular fossa
Glans penis
External urethral orifice (meatus)
Trigone of urinary bladder
Uvula of bladder
Urethral crest
Openings of prostatic ducts
Openings of ejaculatory ducts
Bulbo-urethral (Cowper's) gland
Openings of bulbo-urethral ducts
Prostatic urethra
Intermediate part of (membranous) urethra
Bulbous portion
Pendulous (penile) portion
Spongy (cavernous) urethra
Roof of urethra
Floor of urethra
F. Netter M.D.
C. Machado M.D.



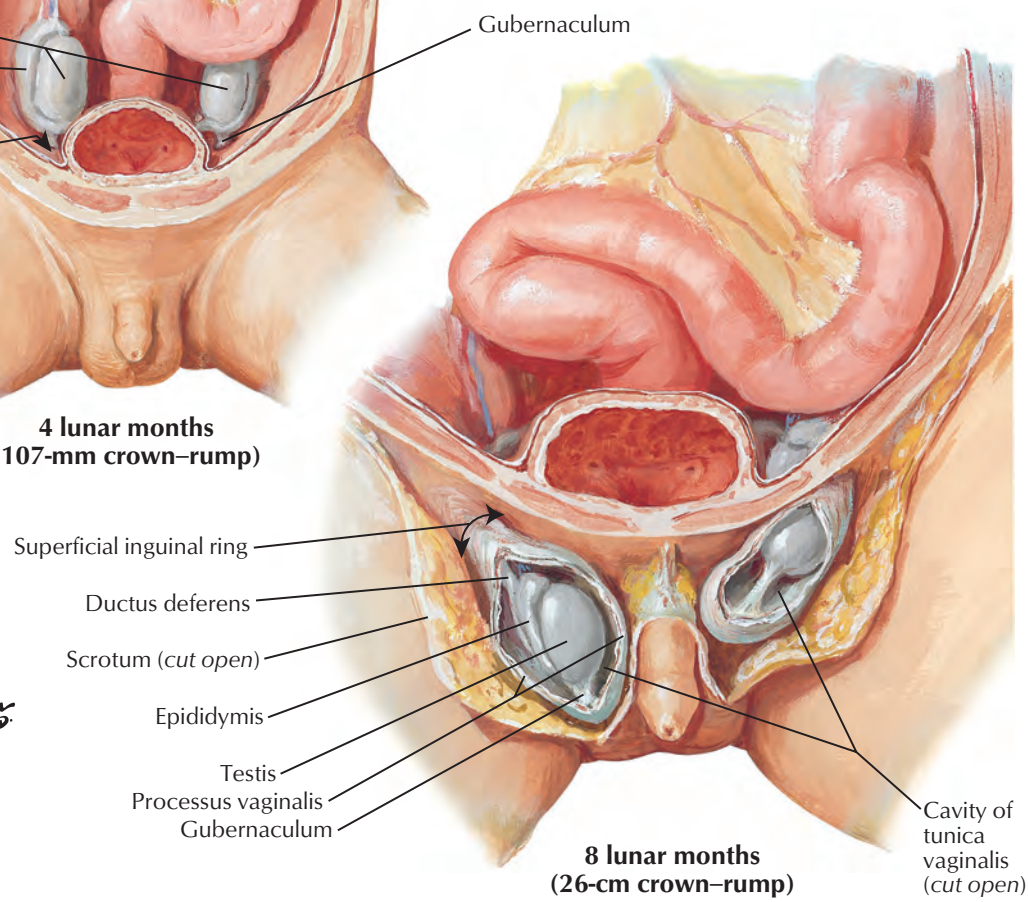
8 weeks
(22.5-mm crown–rump)



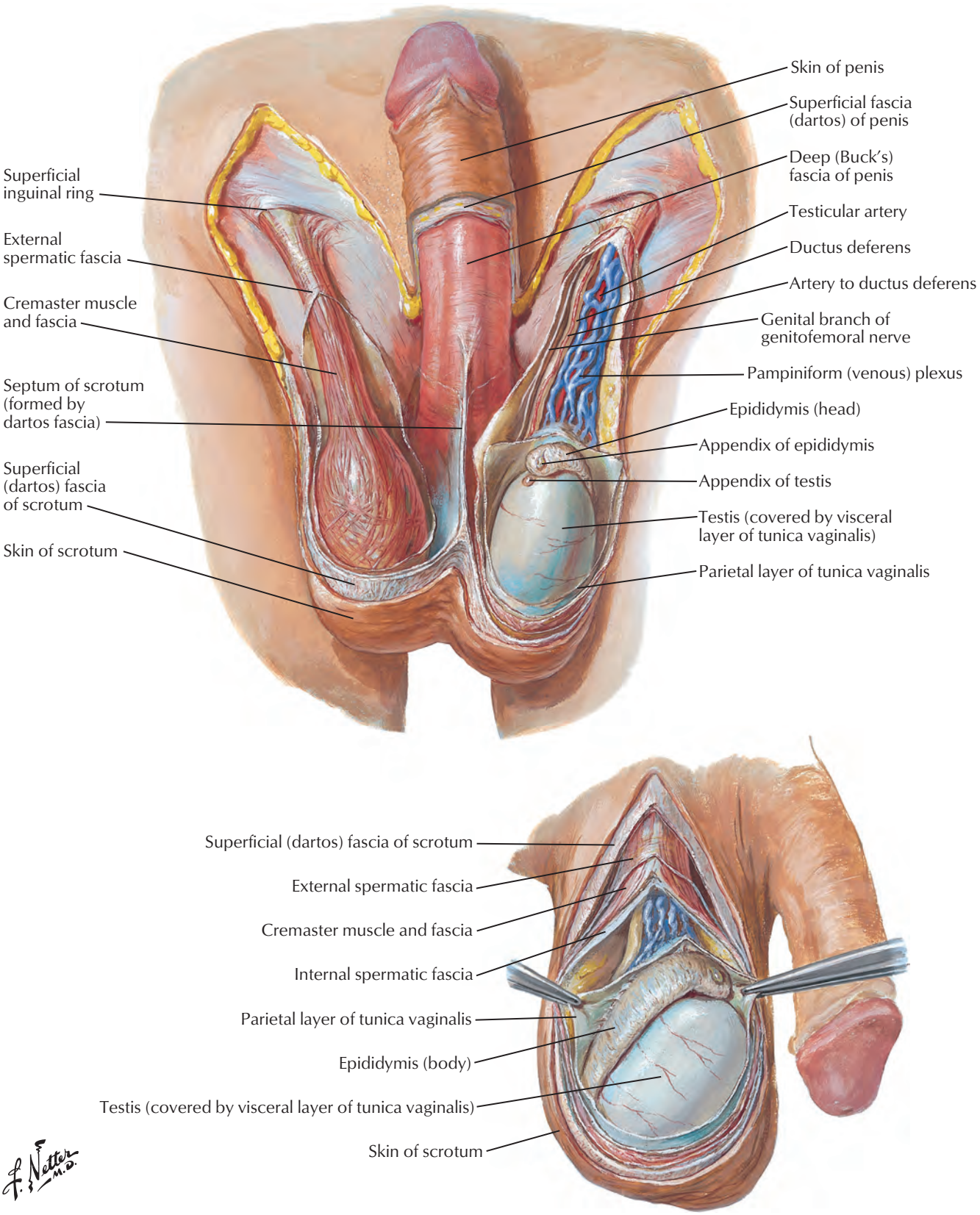
11 weeks
(43-mm crown–rump)



4 lunar months
(107-mm crown–rump)

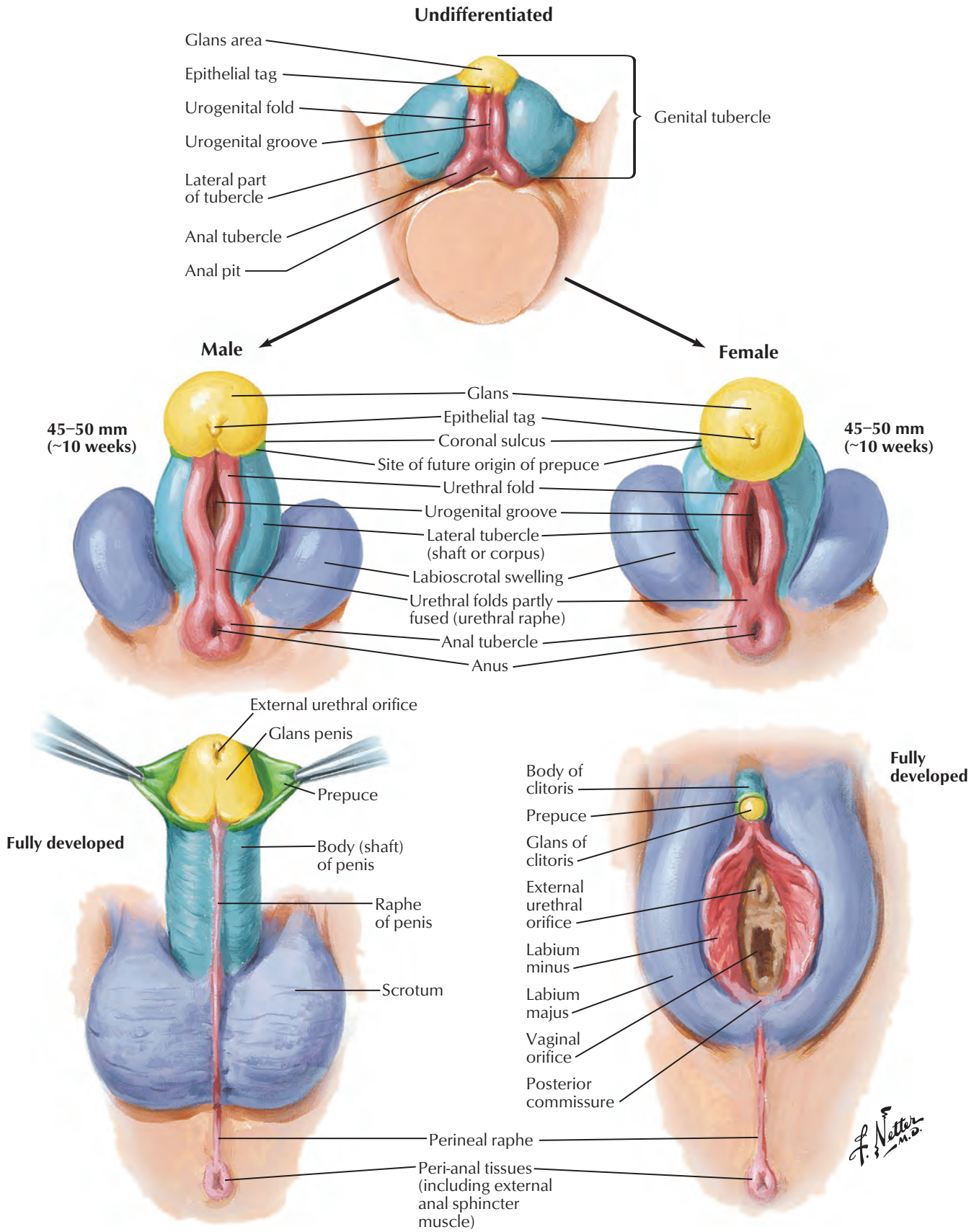


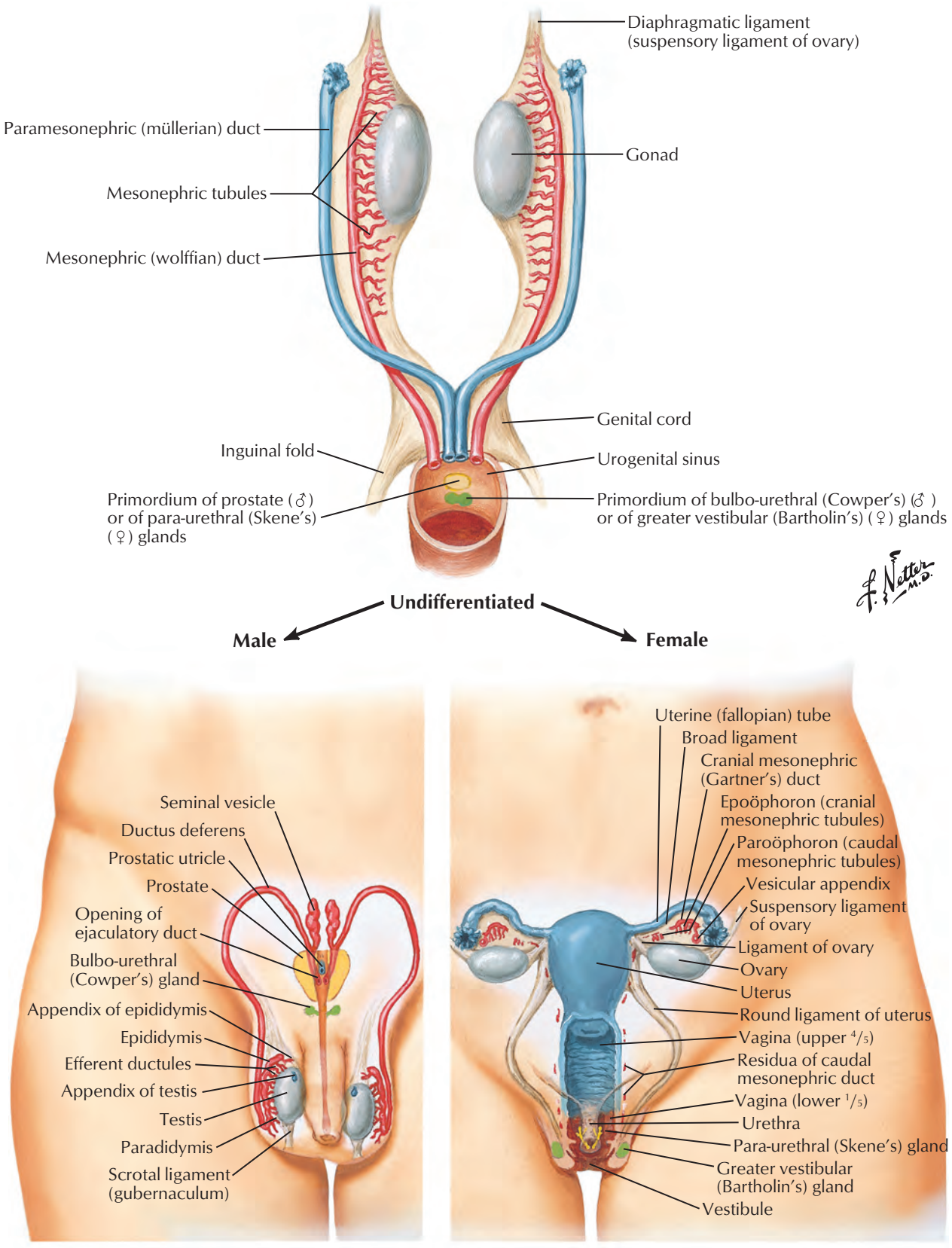
8 lunar months
(26-cm crown–rump)

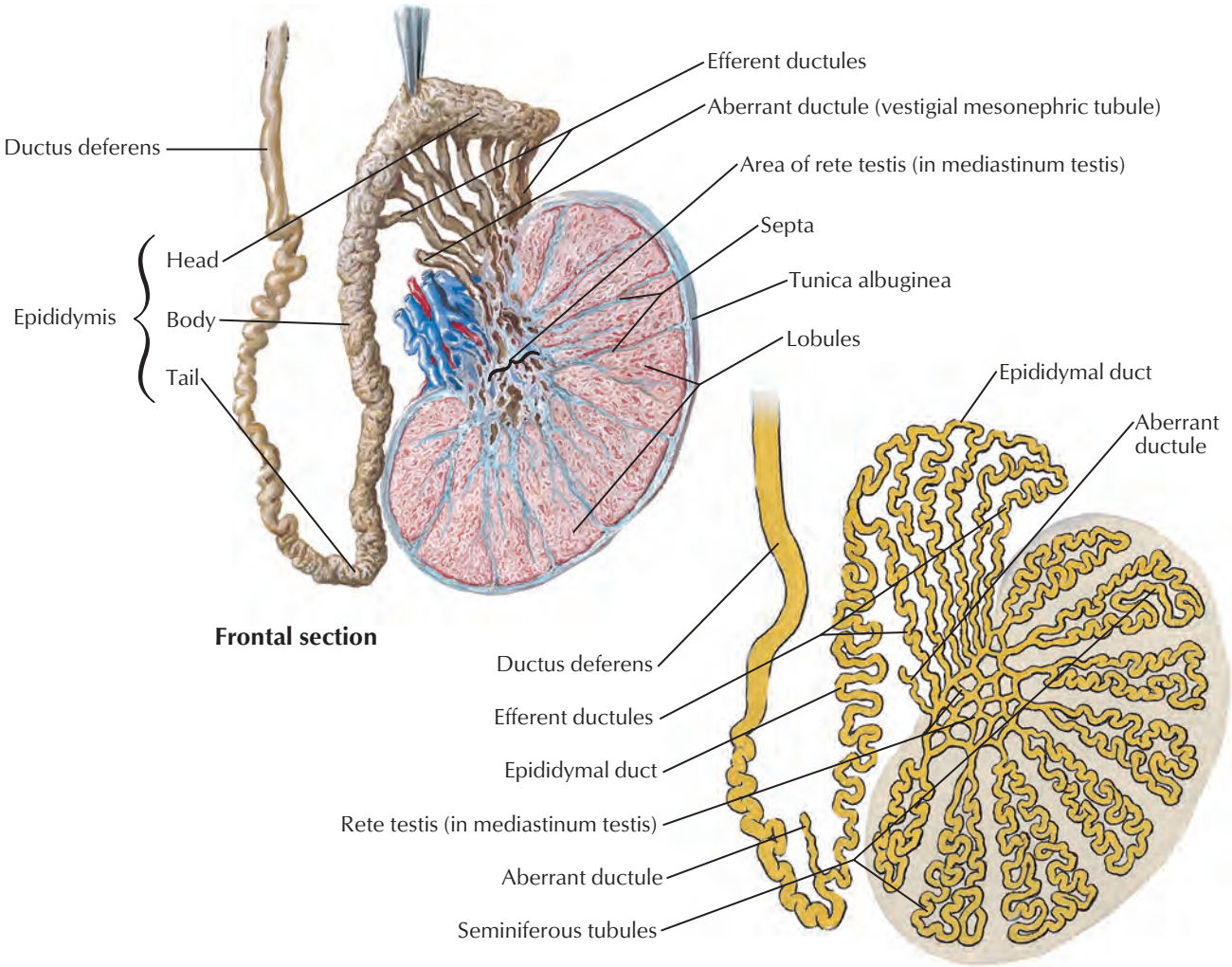

Skin of penis
Superficial fascia (dartos) of penis
Deep (Buck's) fascia of penis
Testicular artery
Ductus deferens
Artery to ductus deferens
Genital branch of genitofemoral nerve
Pampiniform (venous) plexus
Epididymis (head)
Appendix of epididymis
Appendix of testis
Testis (covered by visceral layer of tunica vaginalis)
Parietal layer of tunica vaginalis
Superficial inguinal ring
External spermatic fascia
Cremaster muscle and fascia
Septum of scrotum (formed by dartos fascia)
Superficial (dartos) fascia of scrotum
Skin of scrotum
Superficial (dartos) fascia of scrotum
External spermatic fascia
Cremaster muscle and fascia
Internal spermatic fascia
Parietal layer of tunica vaginalis
Epididymis (body)
Testis (covered by visceral layer of tunica vaginalis)
Skin of scrotum

Homologues of External Genitalia

See also **Plate 354**

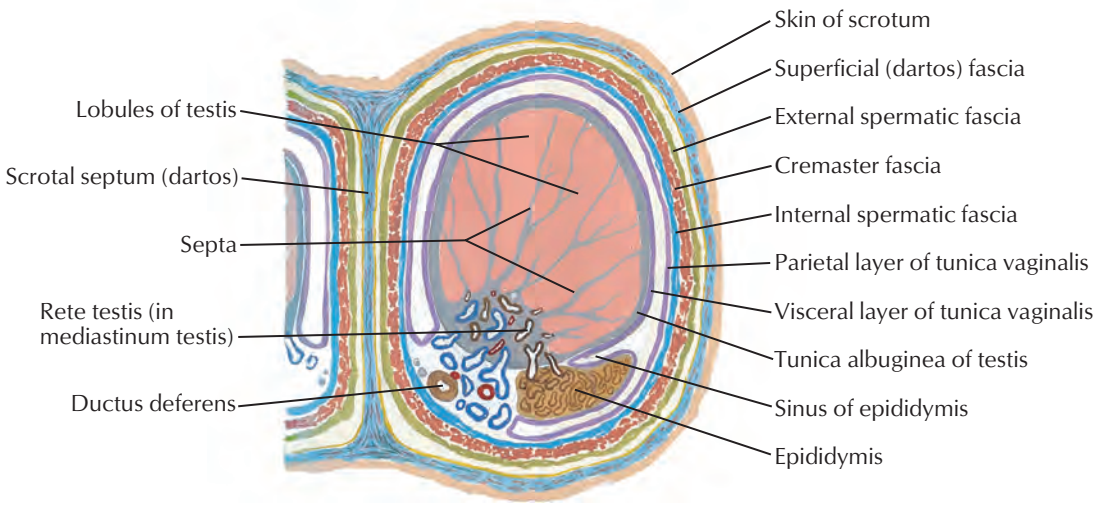



Diaphragmatic ligament
(suspensory ligament of ovary)
Paramesonephric (müllerian) duct
Gonad
Mesonephric tubules
Mesonephric (wolffian) duct
Genital cord
Inguinal fold
Urogenital sinus
Primordium of prostate (♂)
or of para-urethral (Skene's)
(♀) glands
Primordium of bulbo-urethral (Cowper's) (♂)
or of greater vestibular (Bartholin's) (♀) glands
Undifferentiated
Male
Female
Seminal vesicle
Ductus deferens
Prostatic utricle
Prostate
Opening of
ejaculatory duct
Bulbo-urethral
(Cowper's) gland
Appendix of epididymis
Epididymis
Efferent ductules
Appendix of testis
Testis
Paradidymis
Scrotal ligament
(gubernaculum)
Uterine (fallopian) tube
Broad ligament
Cranial mesonephric
(Gartner's) duct
Epoöphoron (cranial
mesonephric tubules)
Paroöphoron (caudal
mesonephric tubules)
Vesicular appendix
Suspensory ligament
of ovary
Ligament of ovary
Ovary
Uterus
Round ligament of uterus
Vagina (upper 4/5)
Residua of caudal
mesonephric duct
Vagina (lower 1/5)
Urethra
Para-urethral (Skene's) gland
Greater vestibular
(Bartholin's) gland
Vestibule

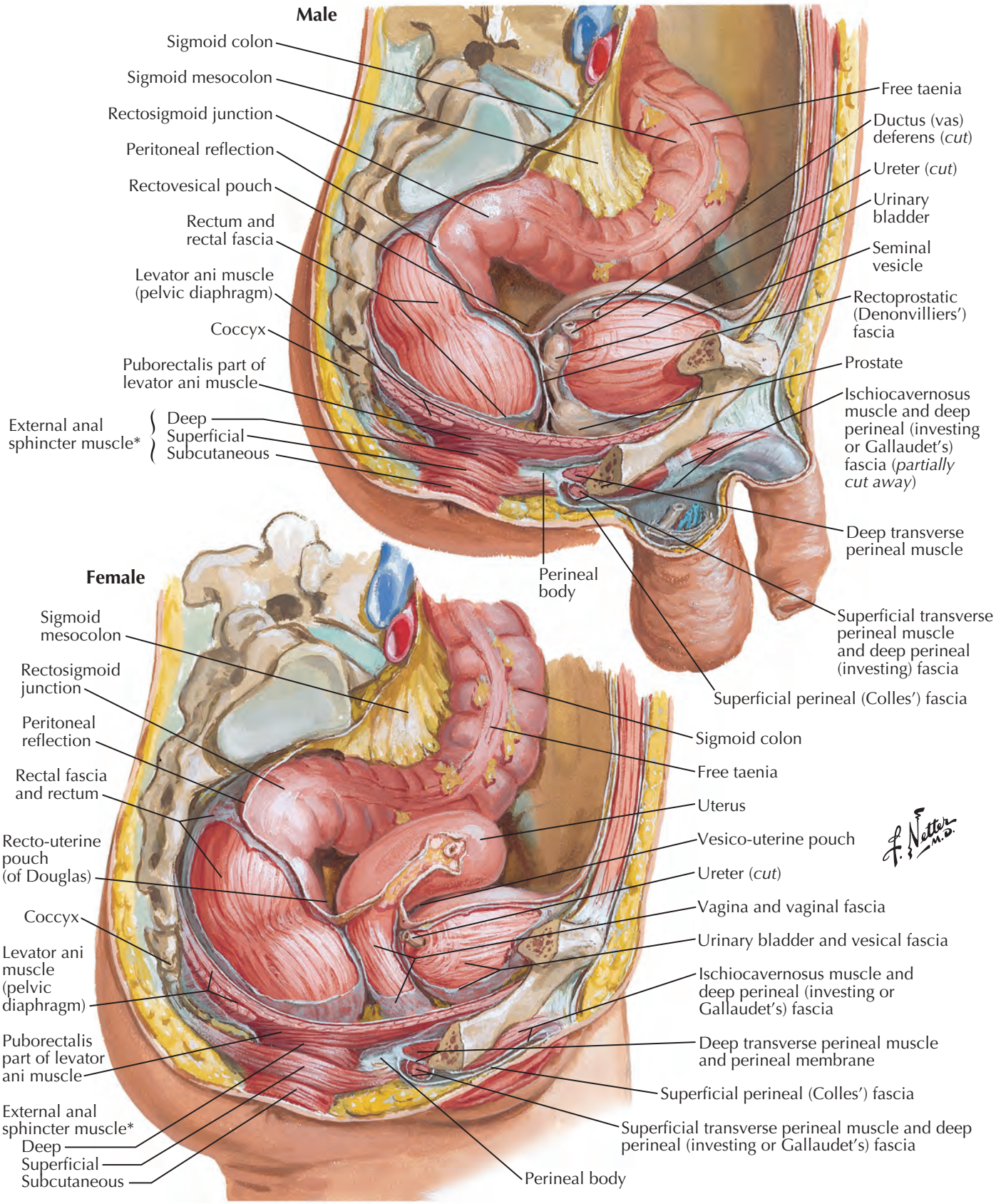


Frontal section

Schema



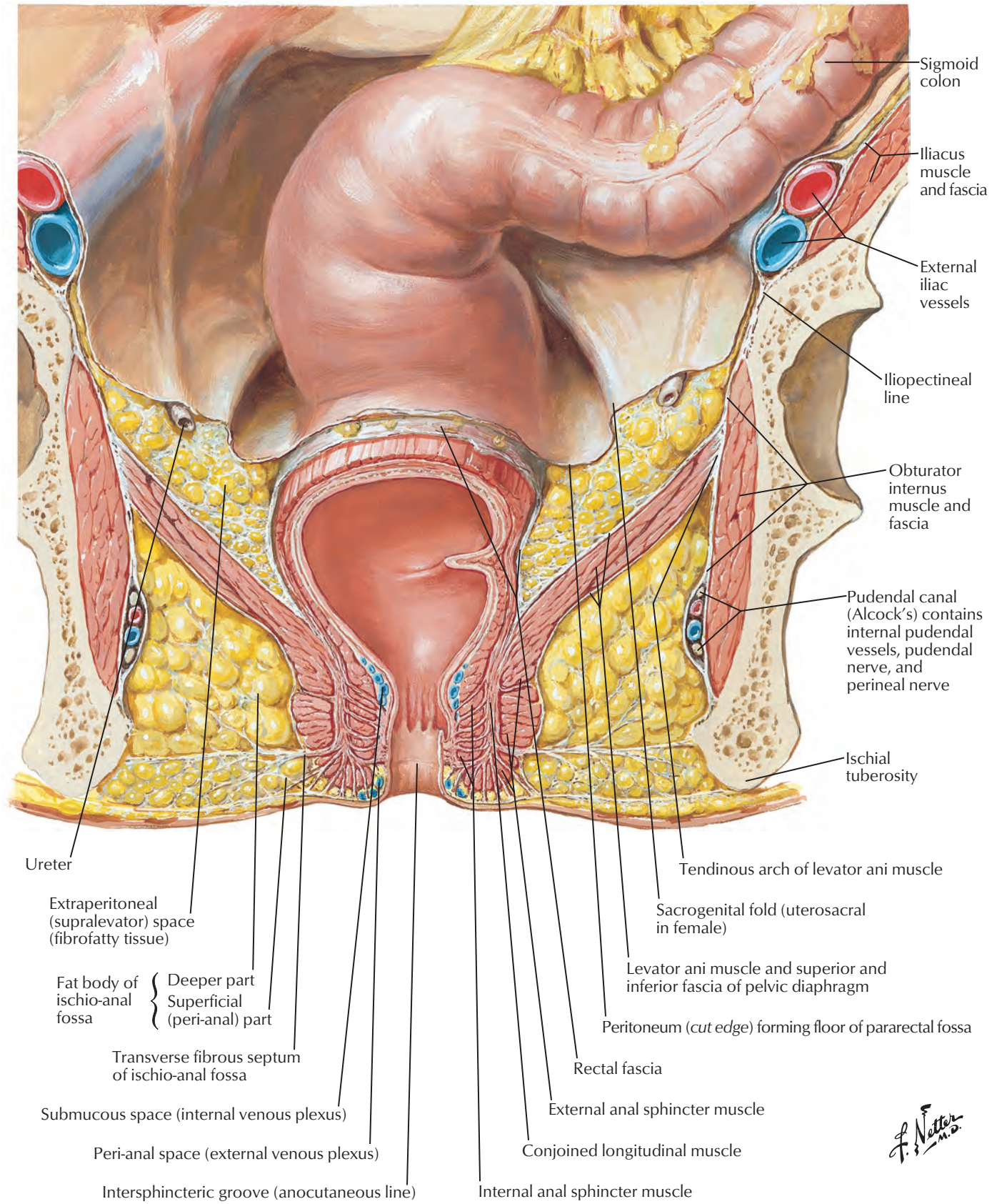
Cross section through scrotum and testis

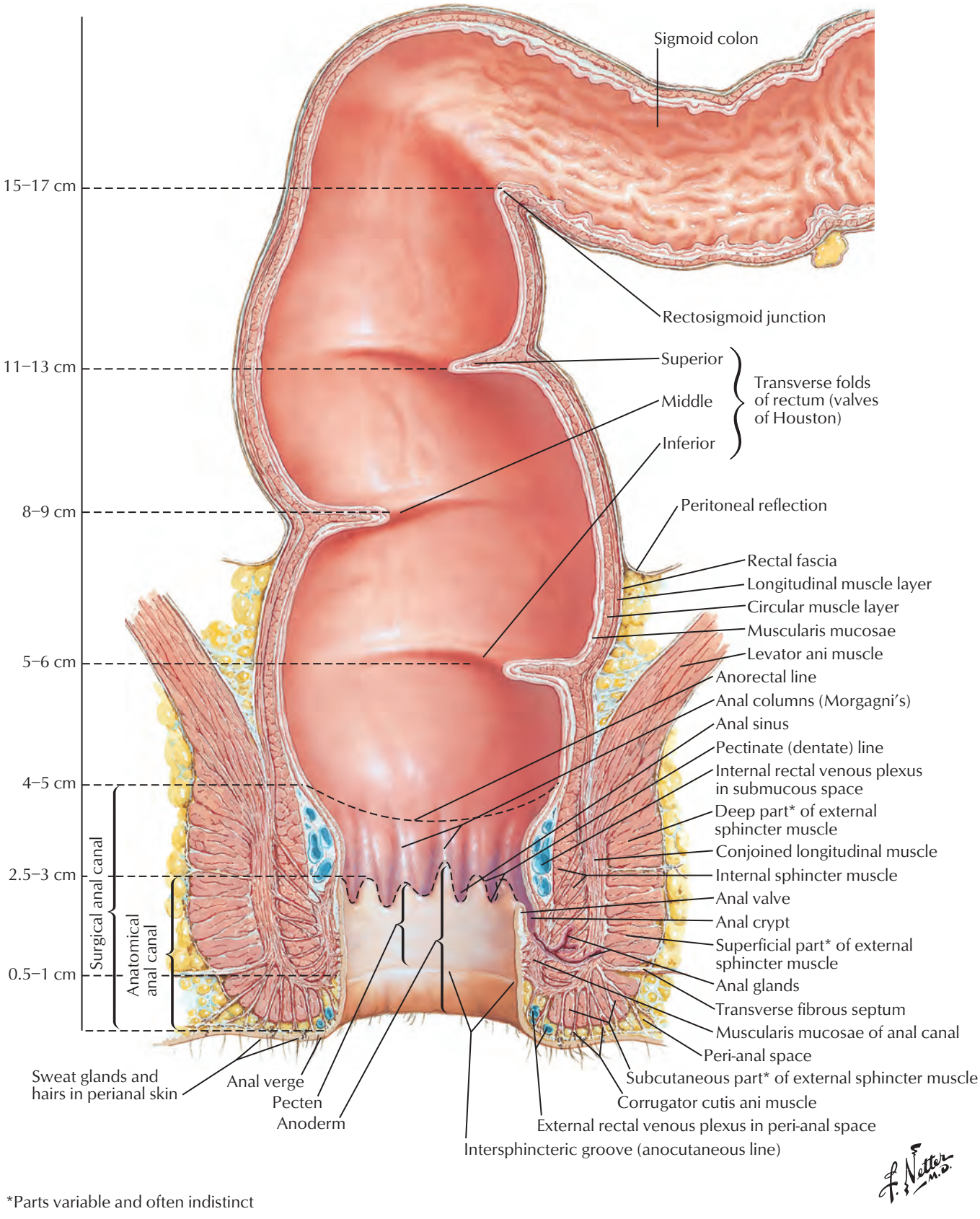


*Parts variable and often indistinct

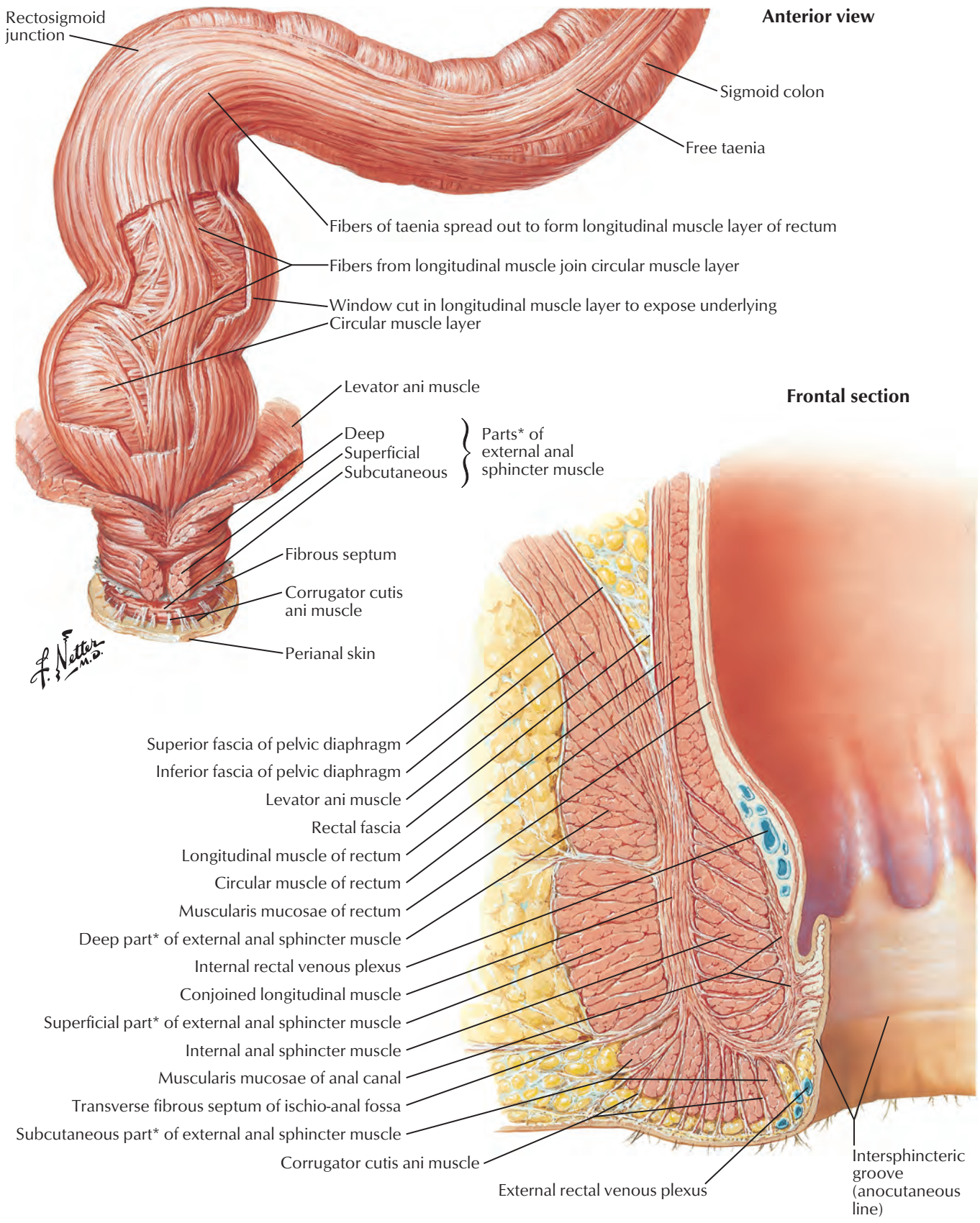
Ischio-anal Fossae

See also **Plates 296, 388**





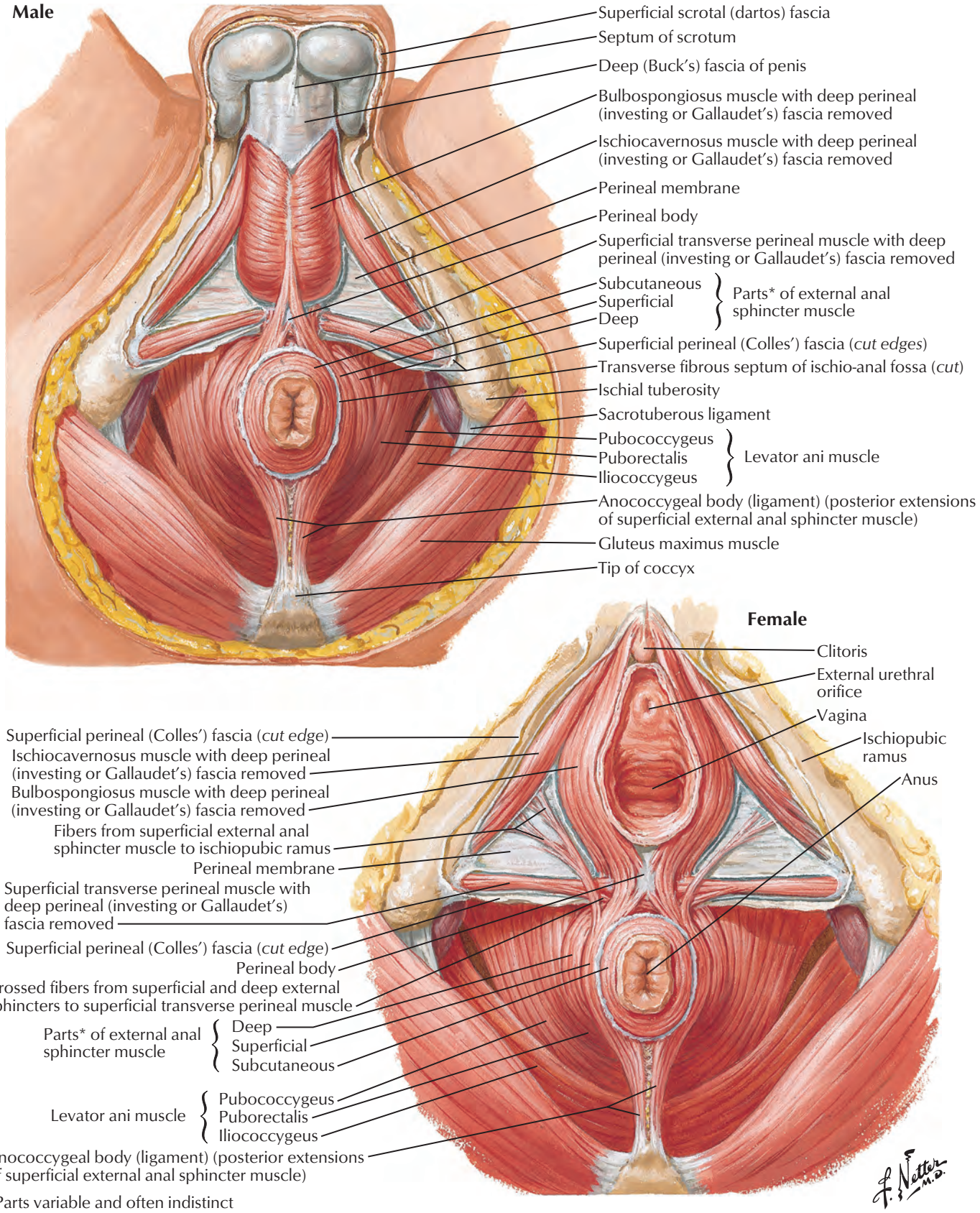
*Parts variable and often indistinct



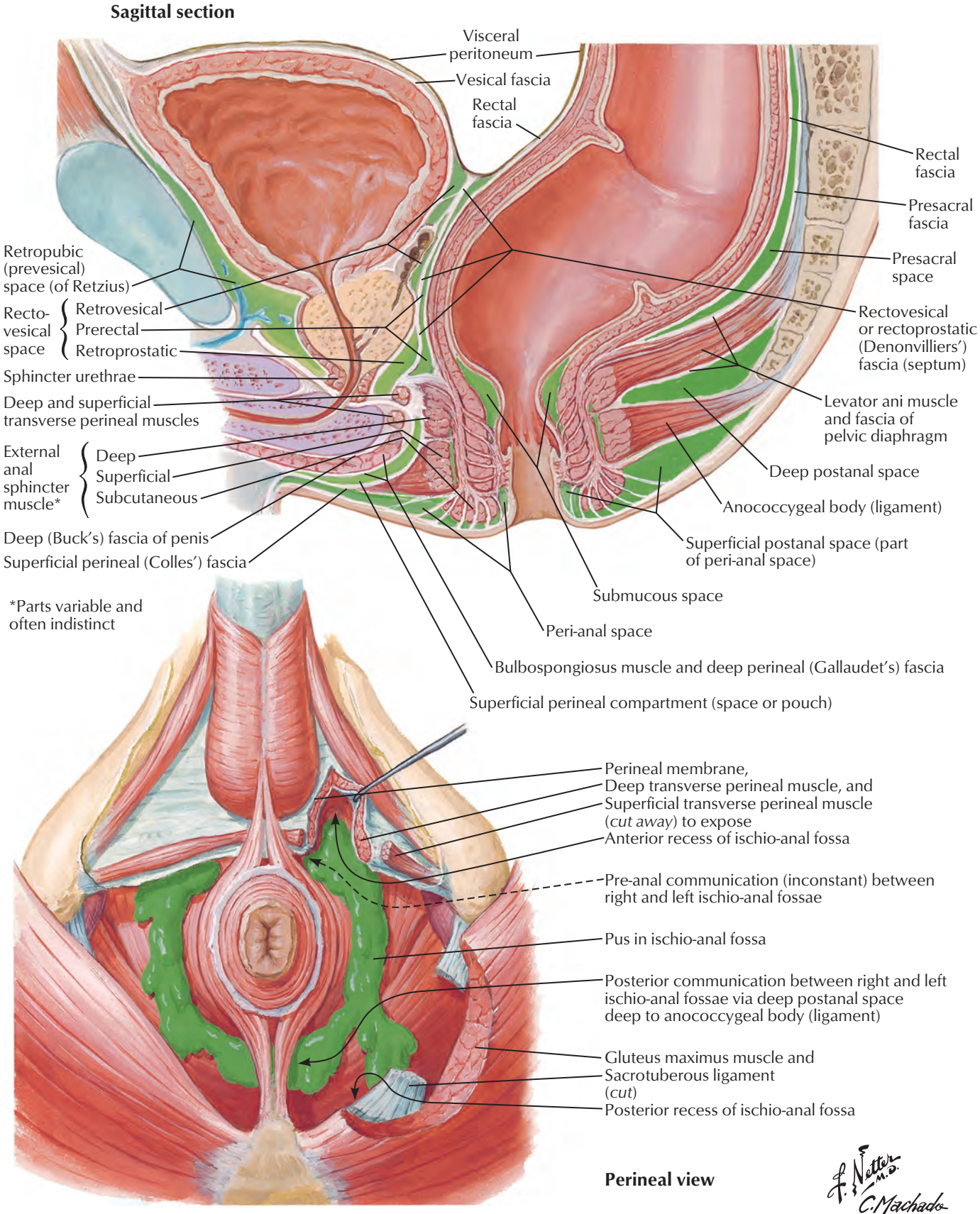
*Parts variable and often indistinct

External Anal Sphincter Muscle: Perineal Views

See also Plates 356, 359



*Parts variable and often indistinct



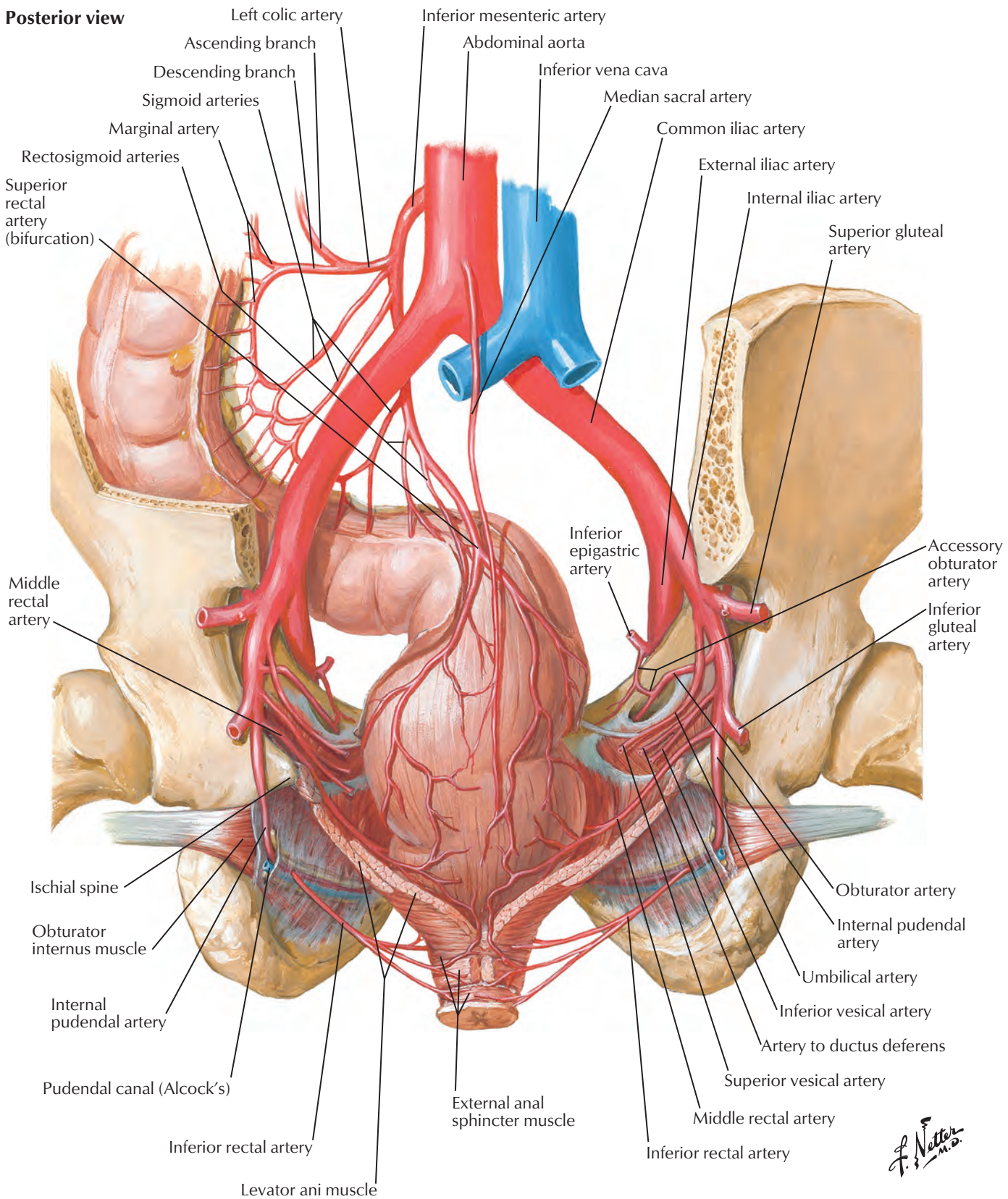
Spread of perineal abscess in perineal spaces

Female

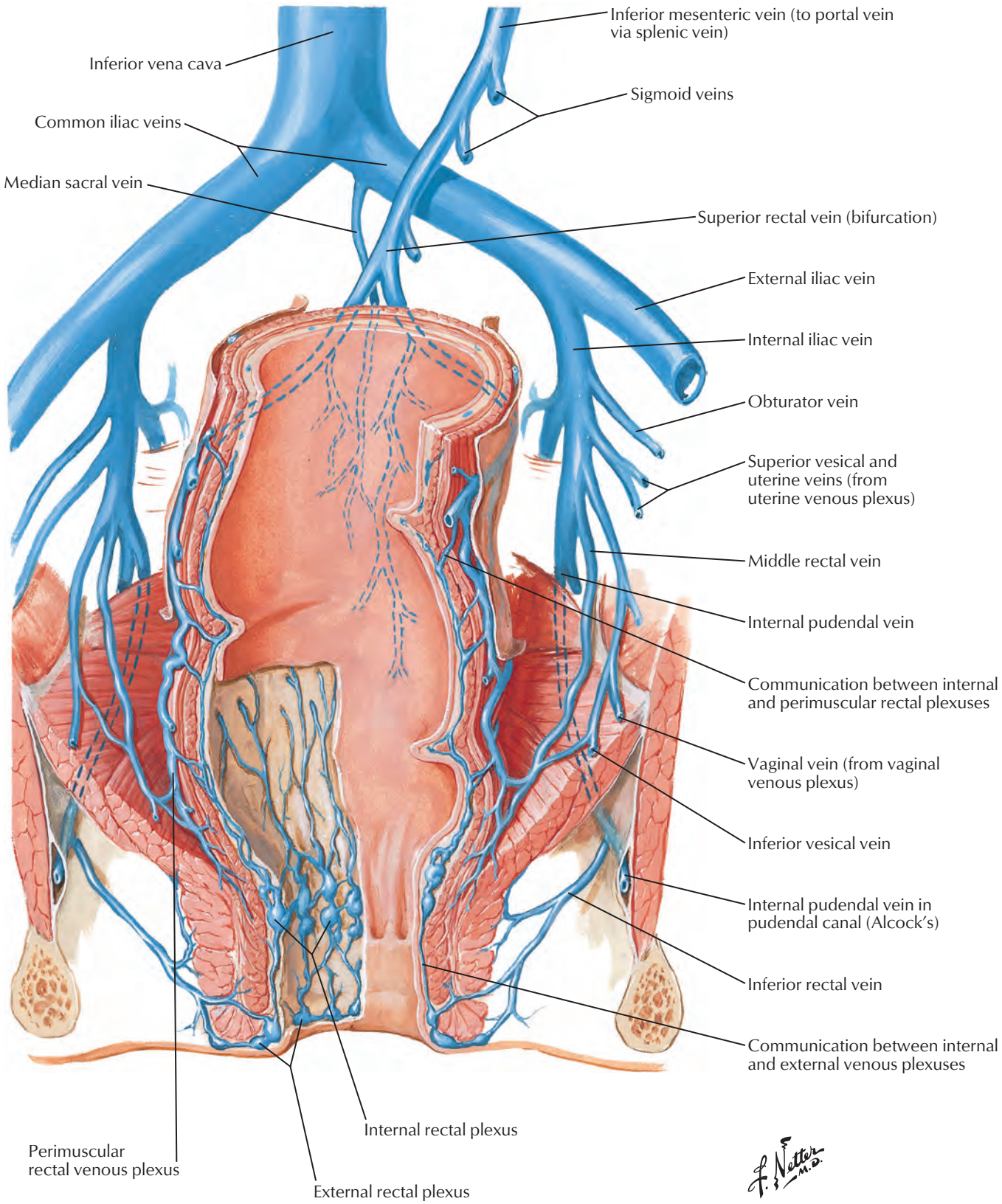
Umbilicus
Rectus abdominis muscle
Fundus of uterus
Urinary bladder
Pubic bone
L5 vertebra
Sacrum
Rectum
Vagina

Male

Liver
Rectus abdominis muscle
Pubic bone
Penis
Scrotum
Urinary bladder
Rectum

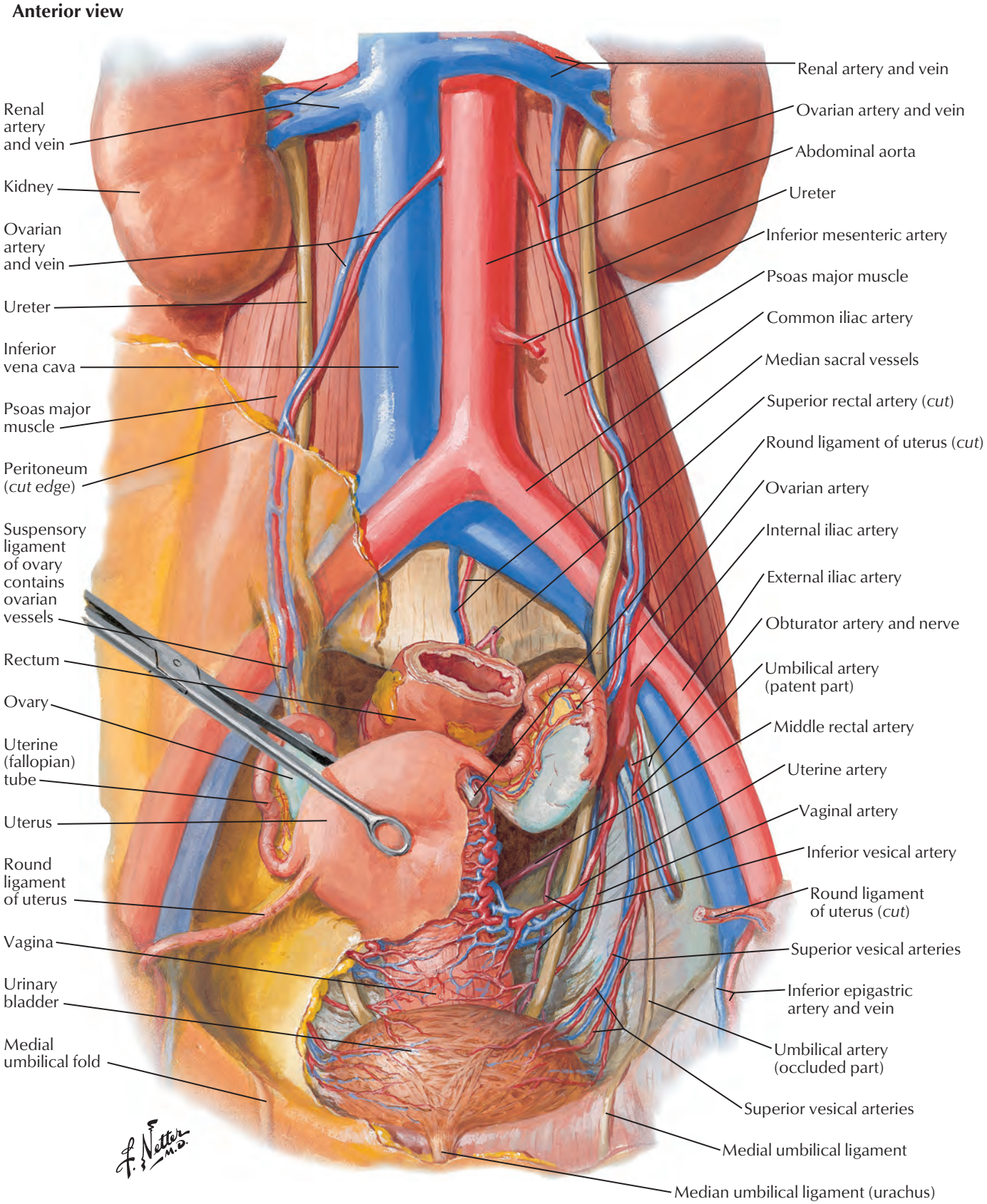

Posterior view
Left colic artery
Inferior mesenteric artery
Ascending branch
Abdominal aorta
Descending branch
Inferior vena cava
Sigmoid arteries
Median sacral artery
Marginal artery
Common iliac artery
Rectosigmoid arteries
External iliac artery
Superior rectal artery (bifurcation)
Internal iliac artery
Superior gluteal artery
Inferior epigastric artery
Accessory obturator artery
Middle rectal artery
Inferior gluteal artery
Ischial spine
Obturator artery
Obturator internus muscle
Internal pudendal artery
Umbilical artery
Internal pudendal artery
Inferior vesical artery
Artery to ductus deferens
Pudendal canal (Alcock's)
Superior vesical artery
External anal sphincter muscle
Middle rectal artery
Inferior rectal artery
Inferior rectal artery
Levator ani muscle

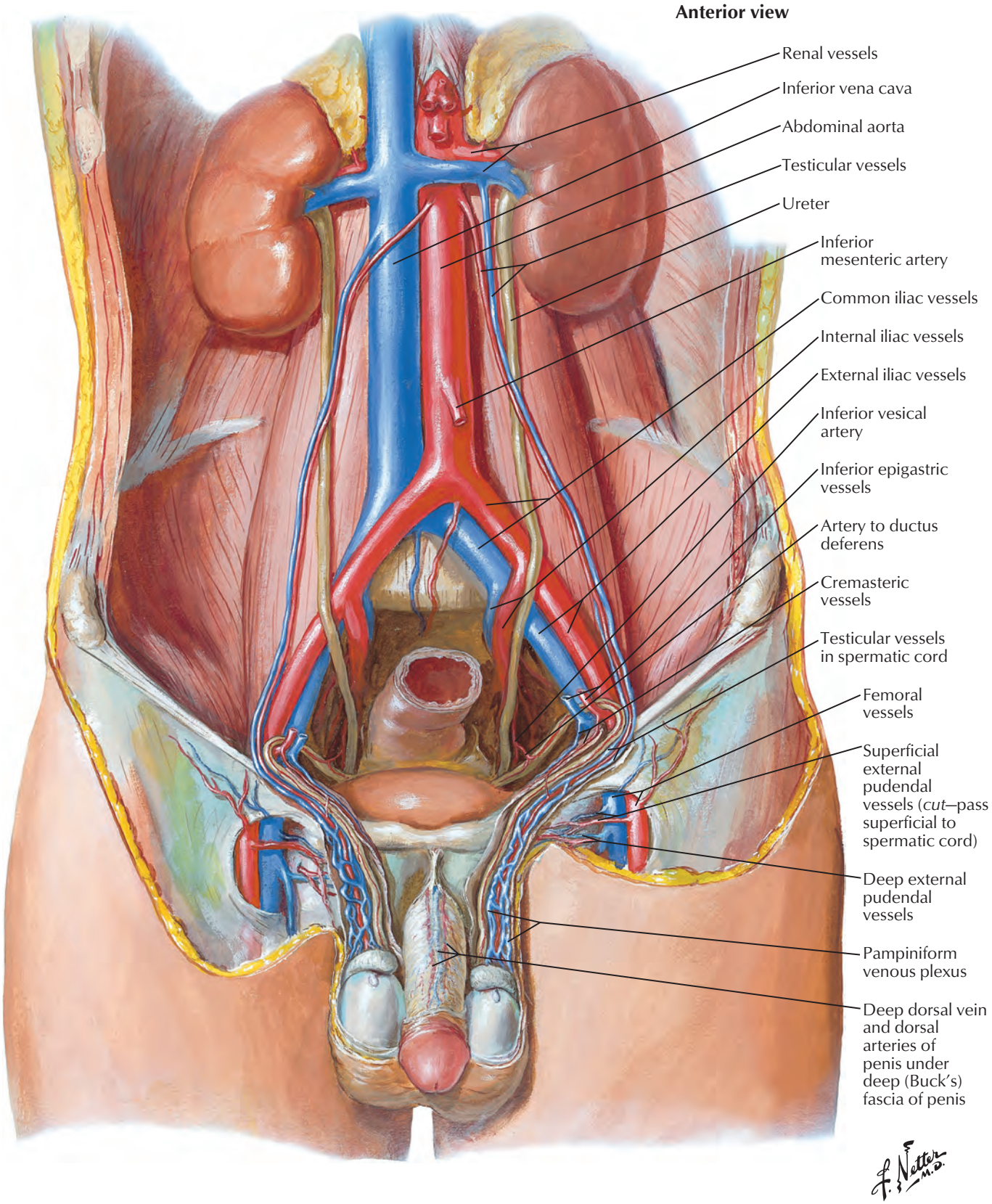
Anterior view

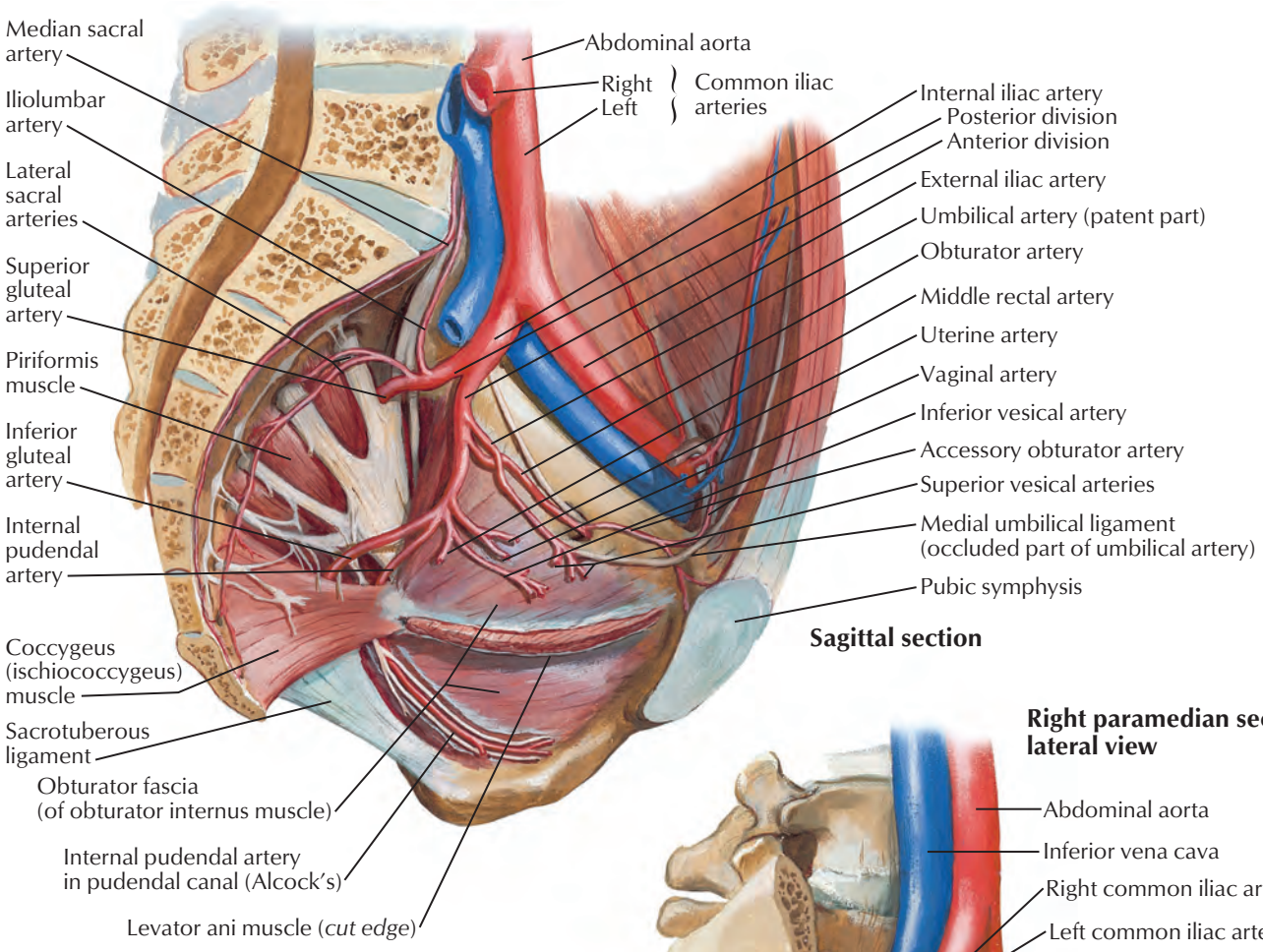


Arteries and Veins of Pelvic Organs: Female

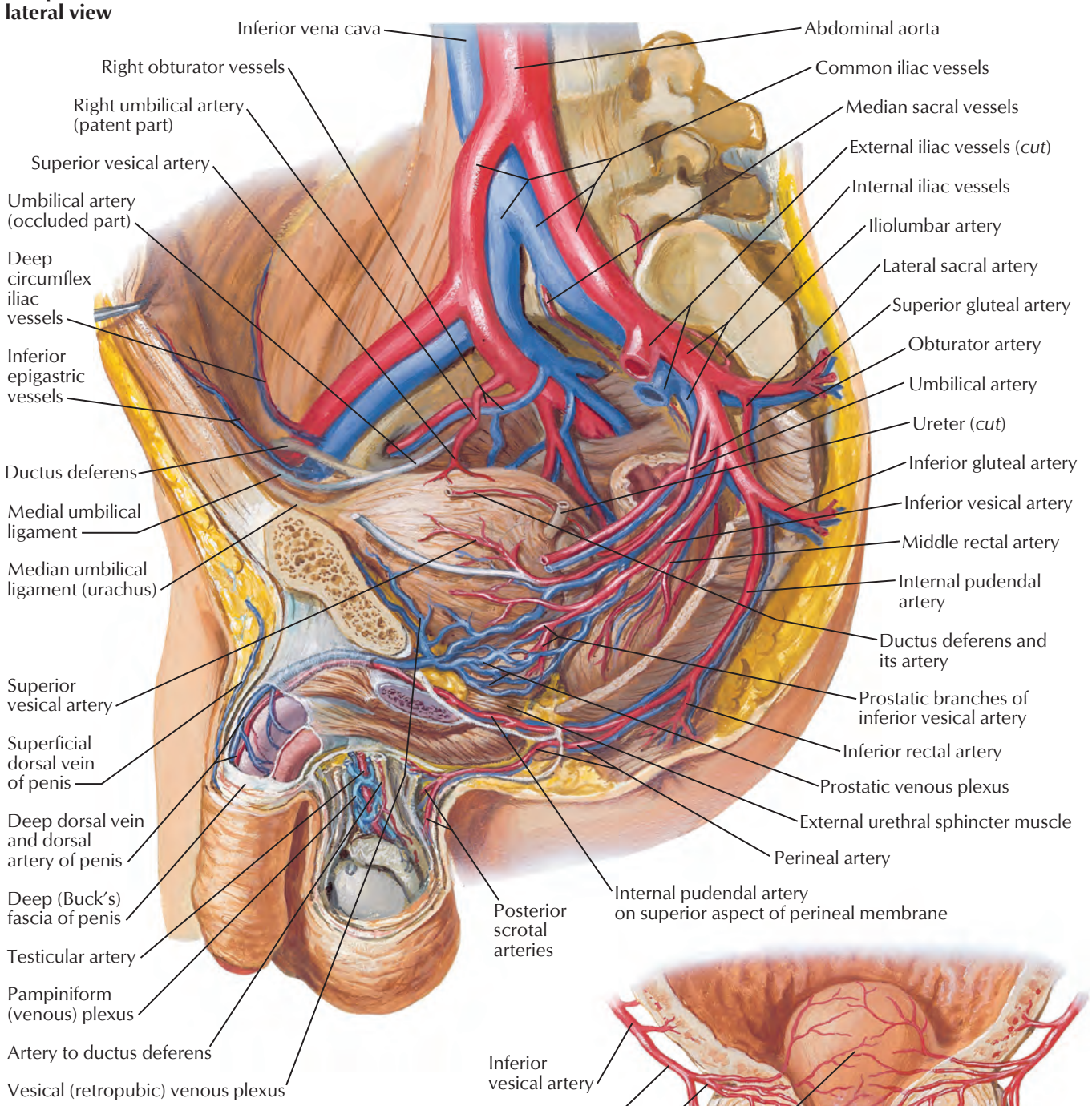
Anterior view

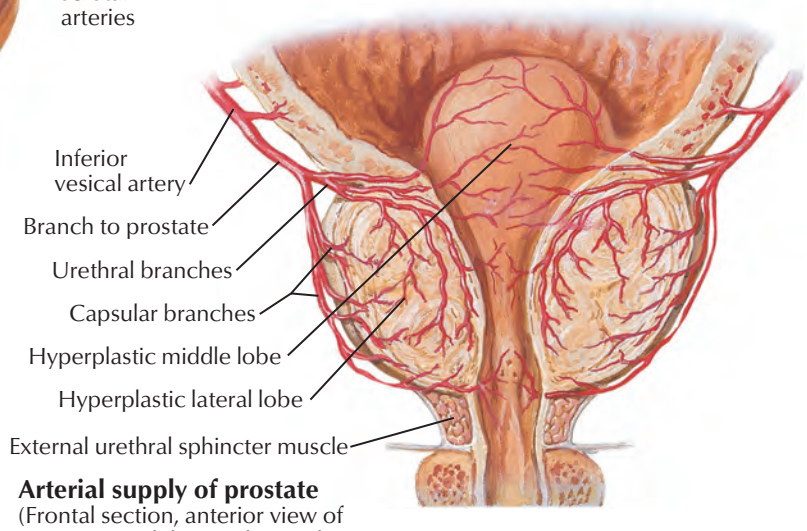



Anterior view
Renal vessels
Inferior vena cava
Abdominal aorta
Testicular vessels
Ureter
Inferior mesenteric artery
Common iliac vessels
Internal iliac vessels
External iliac vessels
Inferior vesical artery
Inferior epigastric vessels
Artery to ductus deferens
Cremasteric vessels
Testicular vessels in spermatic cord
Femoral vessels
Superficial external pudendal vessels (*cut*—pass superficial to spermatic cord)
Deep external pudendal vessels
Pampiniform venous plexus
Deep dorsal vein and dorsal arteries of penis under deep (Buck's) fascia of penis
F. Netter M.D.


Median sacral artery
Iliolumbar artery
Lateral sacral arteries
Superior gluteal artery
Piriformis muscle
Inferior gluteal artery
Internal pudendal artery
Coccygeus (ischiococcygeus) muscle
Sacrotuberous ligament
Obturator fascia (of obturator internus muscle)
Internal pudendal artery in pudendal canal (Alcock's)
Levator ani muscle (cut edge)
Abdominal aorta
Right
Left
Common iliac arteries
Internal iliac artery
Posterior division
Anterior division
External iliac artery
Umbilical artery (patent part)
Obturator artery
Middle rectal artery
Uterine artery
Vaginal artery
Inferior vesical artery
Accessory obturator artery
Superior vesical arteries
Medial umbilical ligament (occluded part of umbilical artery)
Pubic symphysis
Sagittal section
Right paramedian section: lateral view
Abdominal aorta
Inferior vena cava
Right common iliac artery
Left common iliac artery
Ureters
External iliac artery (cut)
Internal iliac artery
Posterior division
Anterior division
Superior gluteal artery
Umbilical artery (patent part)
Obturator artery
Piriformis muscle
Internal pudendal artery
Inferior gluteal artery
Coccygeus (ischiococcygeus) muscle
Middle rectal artery
Uterine artery
Vaginal artery
Inferior vesical artery
Internal pudendal artery
Inferior rectal artery
Superior vesical arteries
Medial umbilical ligament (occluded distal part of umbilical artery)
Obturator canal
Obturator internus muscle
Levator ani muscle

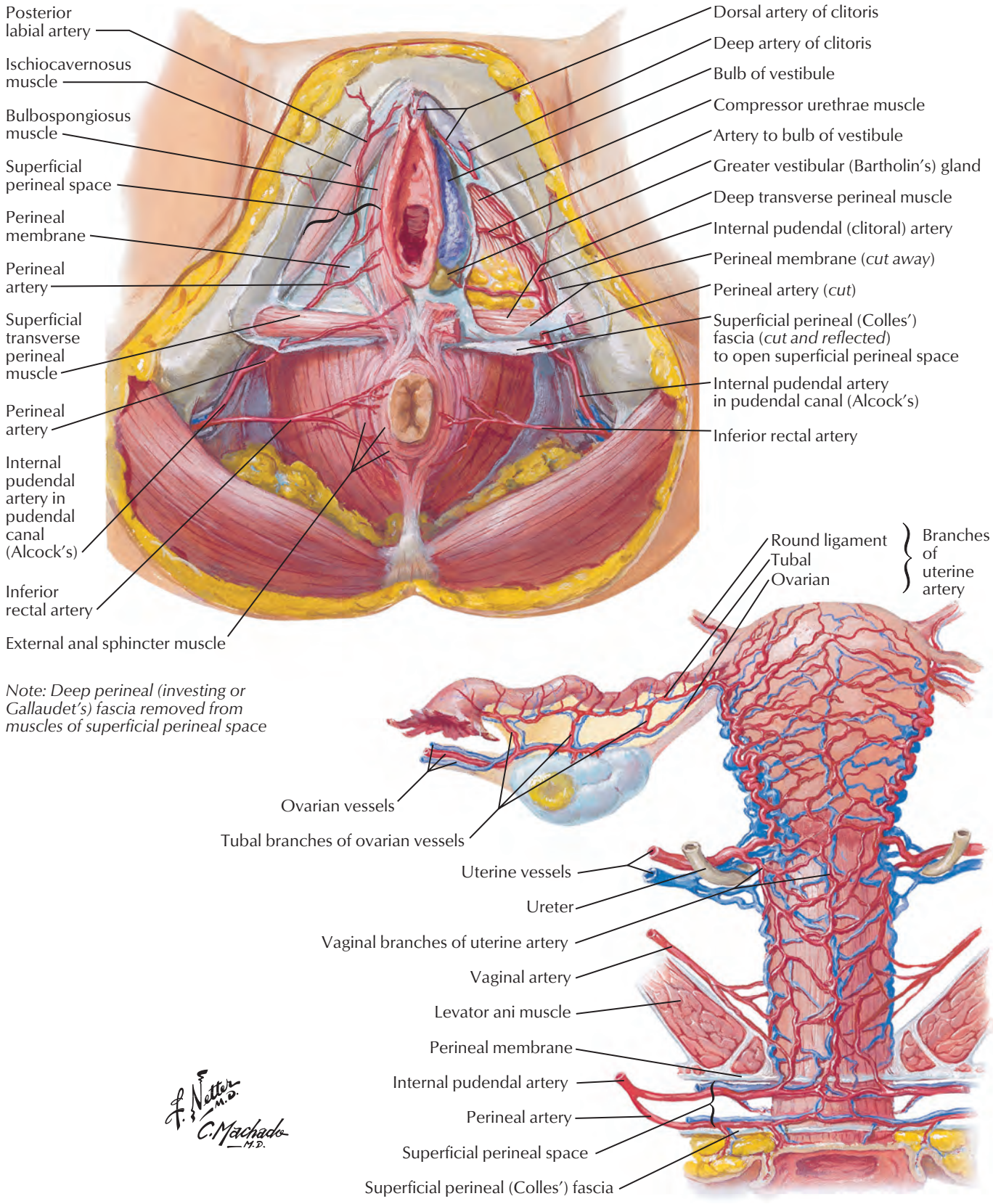
Left paramedian section: lateral view





Arterial supply of prostate
(Frontal section, anterior view of specimen with benign hyperplasia)

F. Netter M.D. C. Machado M.D.



Note: Deep perineal (investing or Gallaudet's) fascia removed from muscles of superficial perineal space

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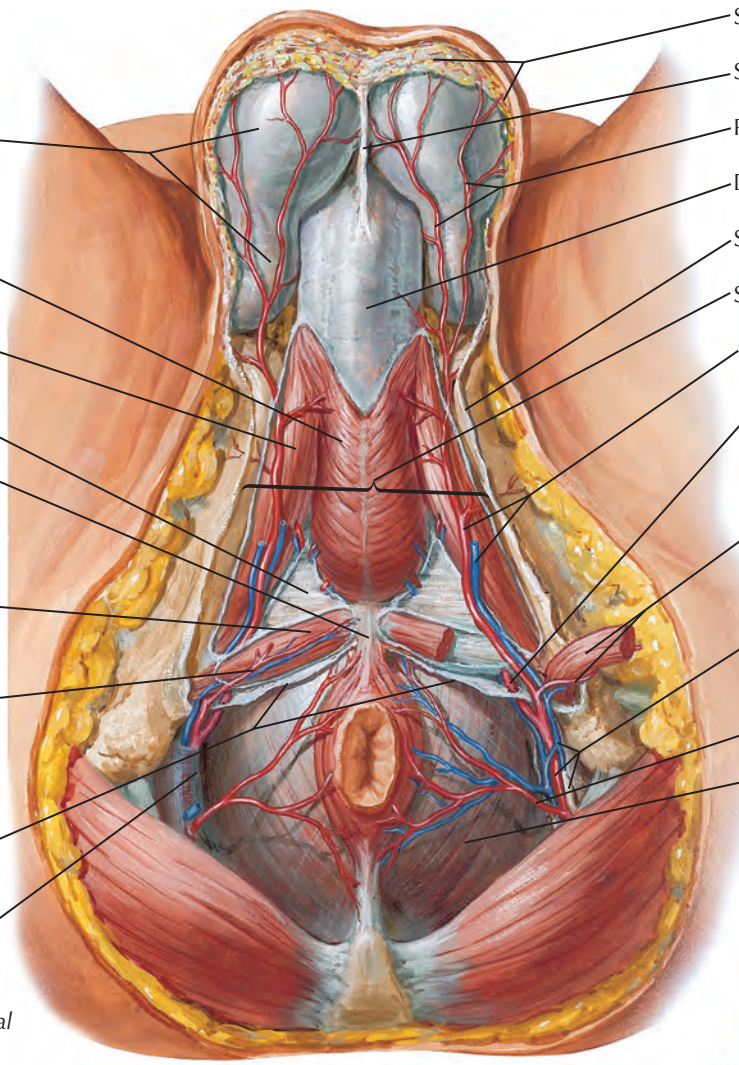
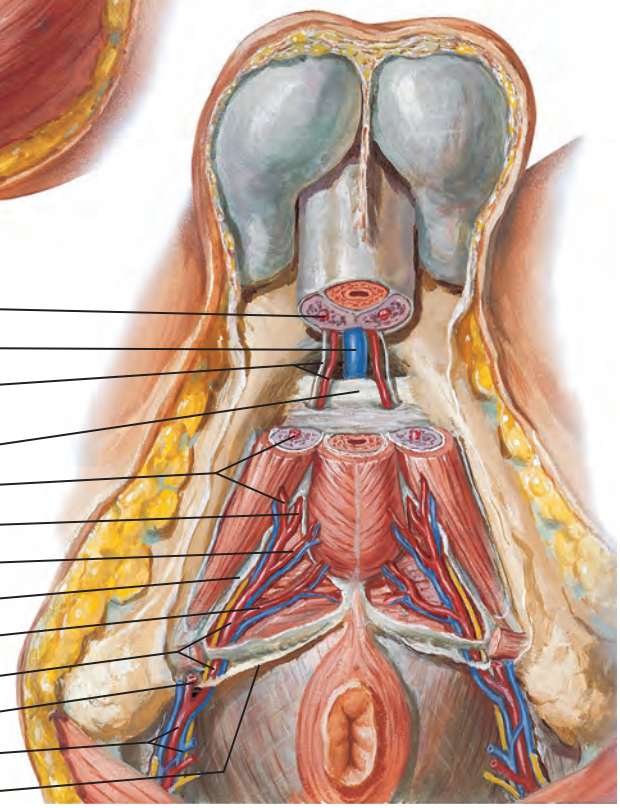
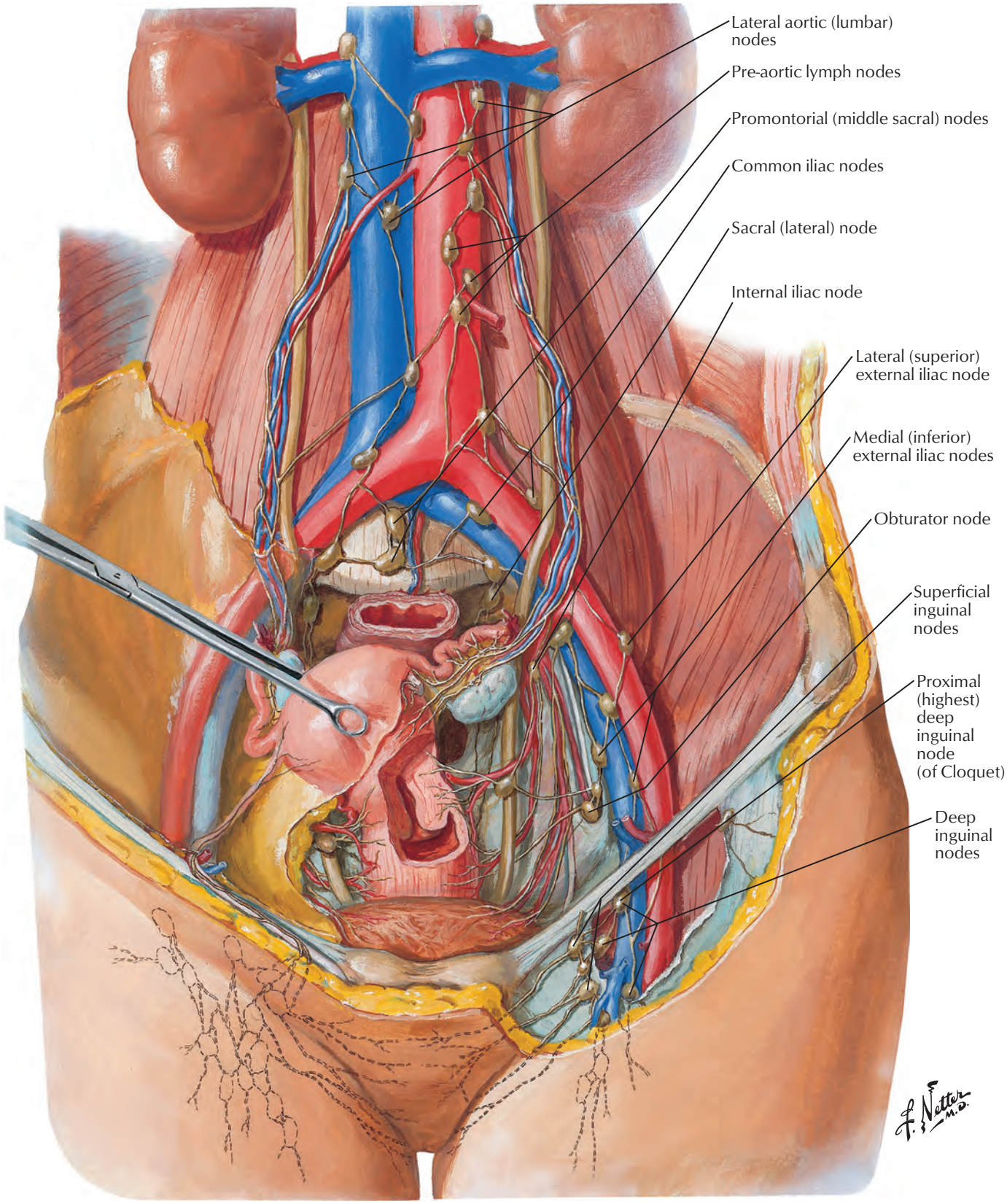
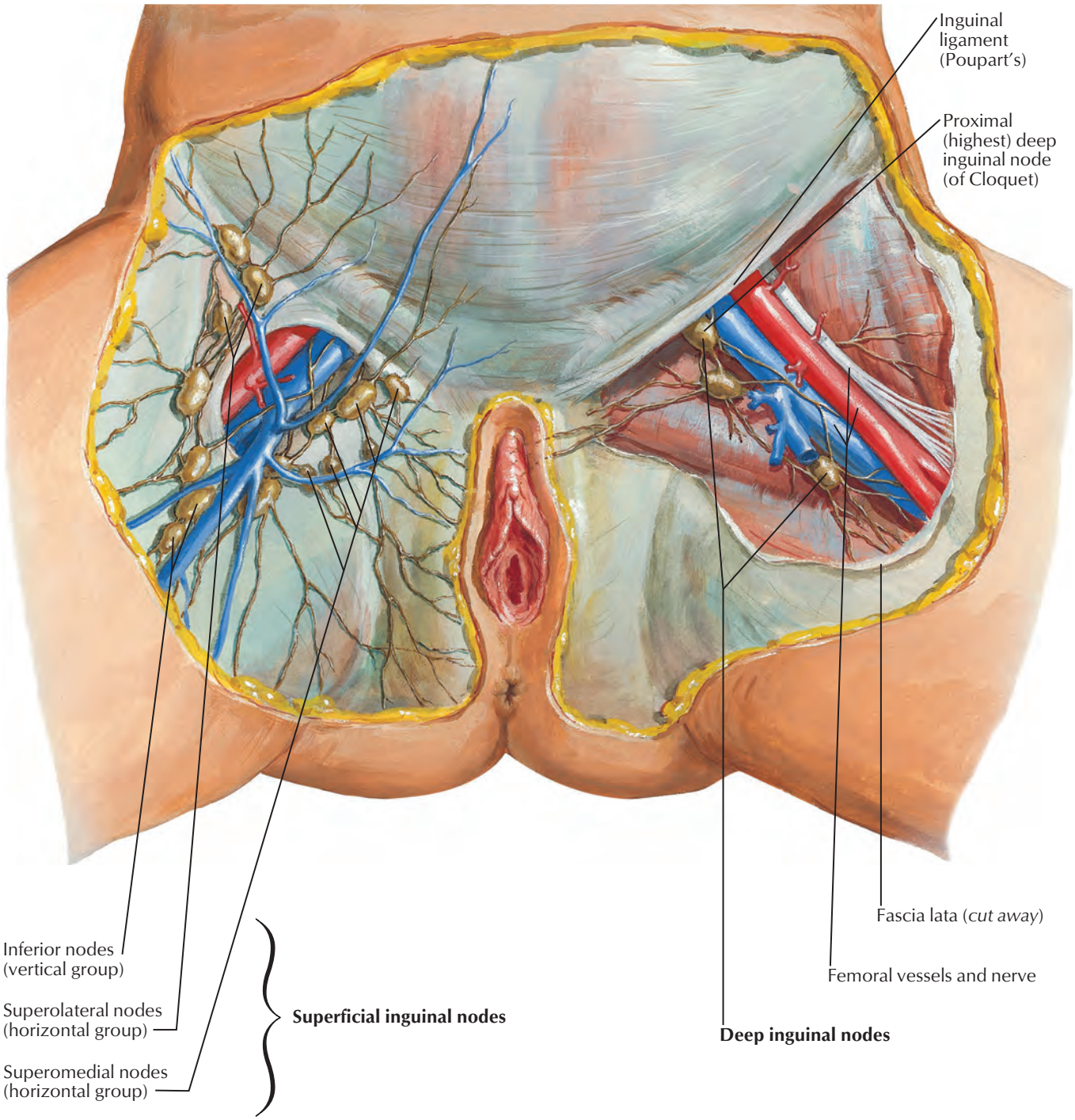
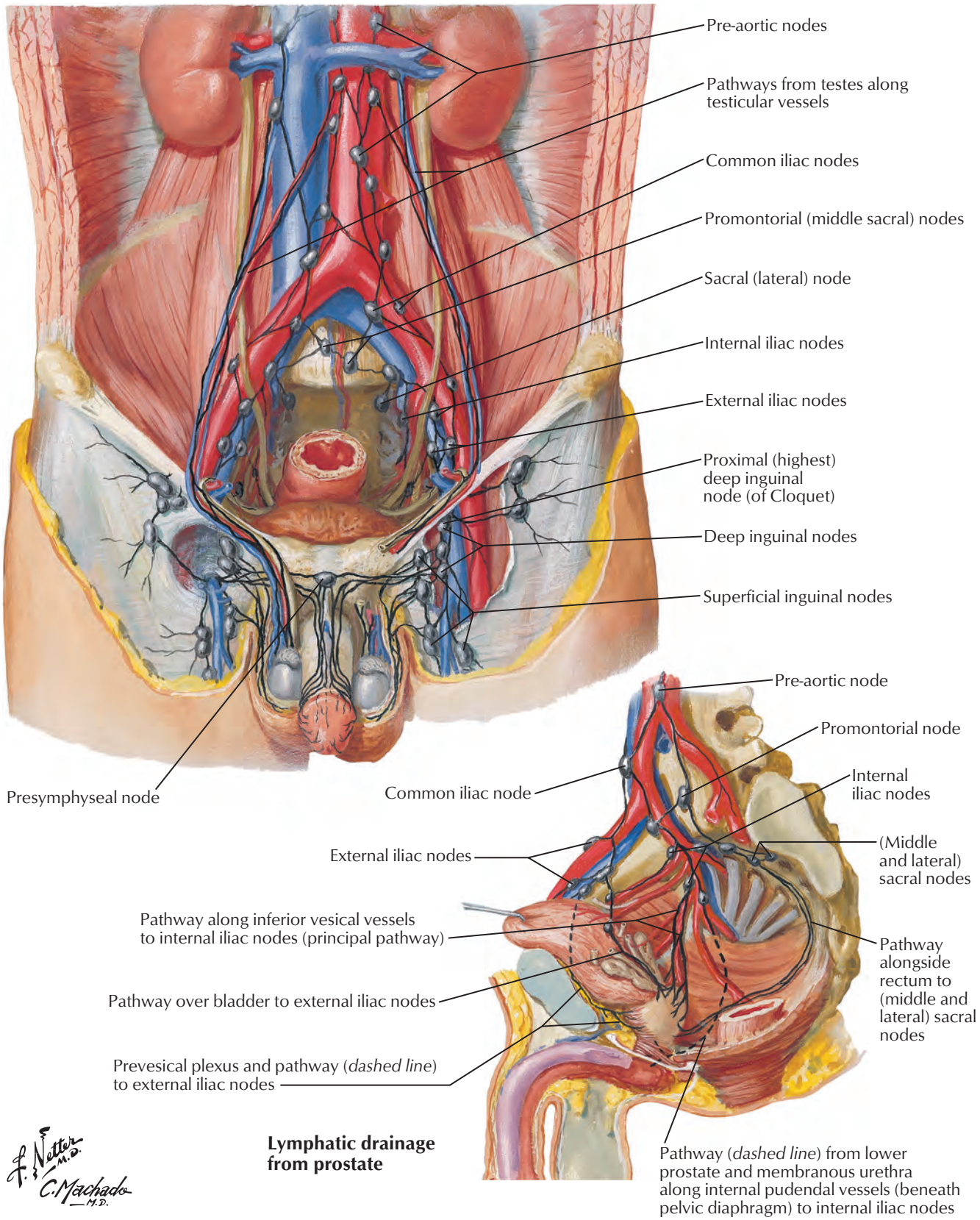


Note: Deep perineal (investing or Gallaudet's) fascia removed from muscles of superficial perineal space

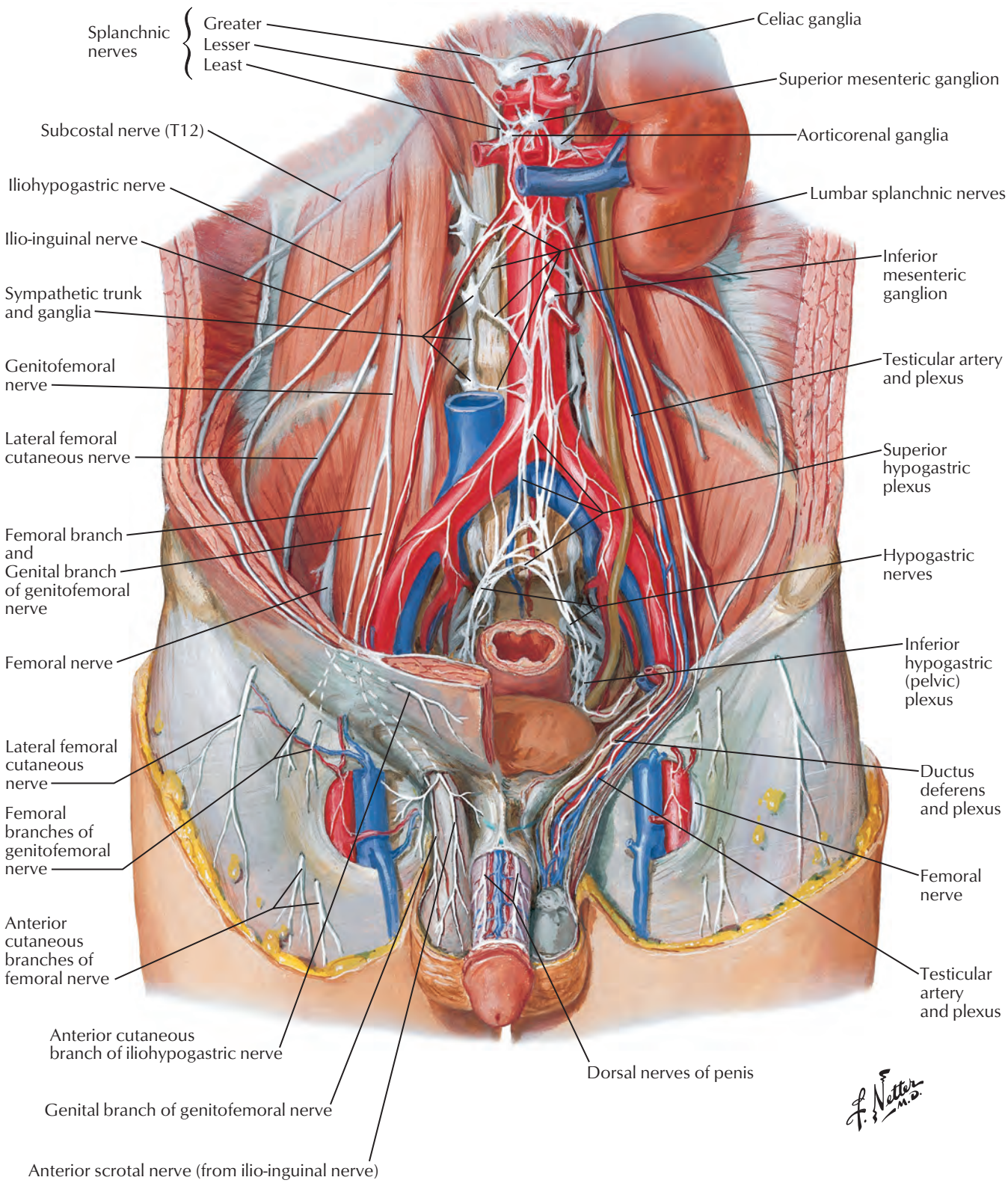



Lateral aortic (lumbar) nodes
Pre-aortic lymph nodes
Promontorial (middle sacral) nodes
Common iliac nodes
Sacral (lateral) node
Internal iliac node
Lateral (superior) external iliac node
Medial (inferior) external iliac nodes
Obturator node
Superficial inguinal nodes
Proximal (highest) deep inguinal node (of Cloquet)
Deep inguinal nodes

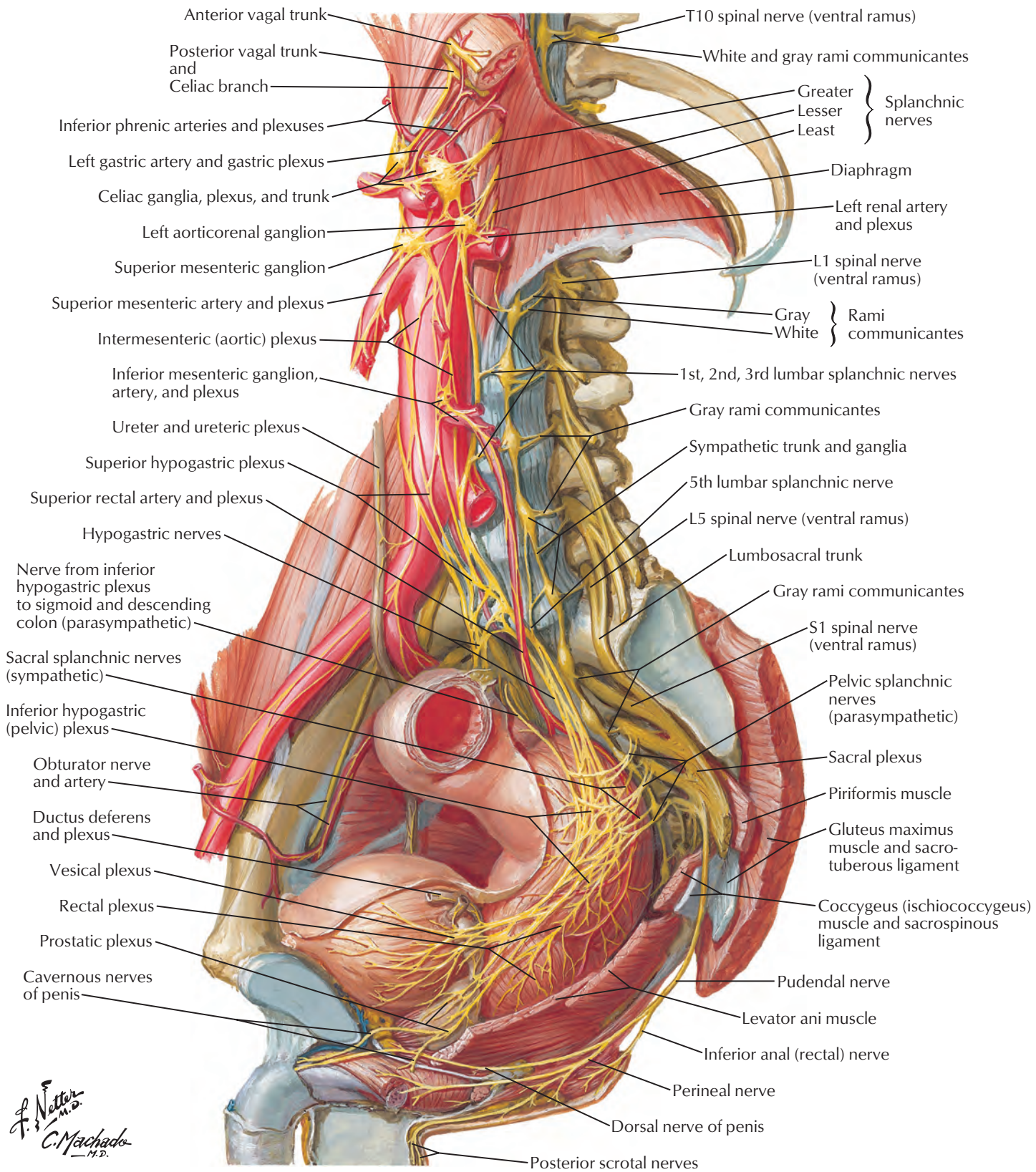

Inguinal ligament (Poupart's)
Proximal (highest) deep inguinal node (of Cloquet)
Fascia lata (*cut away*)
Femoral vessels and nerve
Inferior nodes (vertical group)
Superolateral nodes (horizontal group)
Superomedial nodes (horizontal group)
Superficial inguinal nodes
Deep inguinal nodes

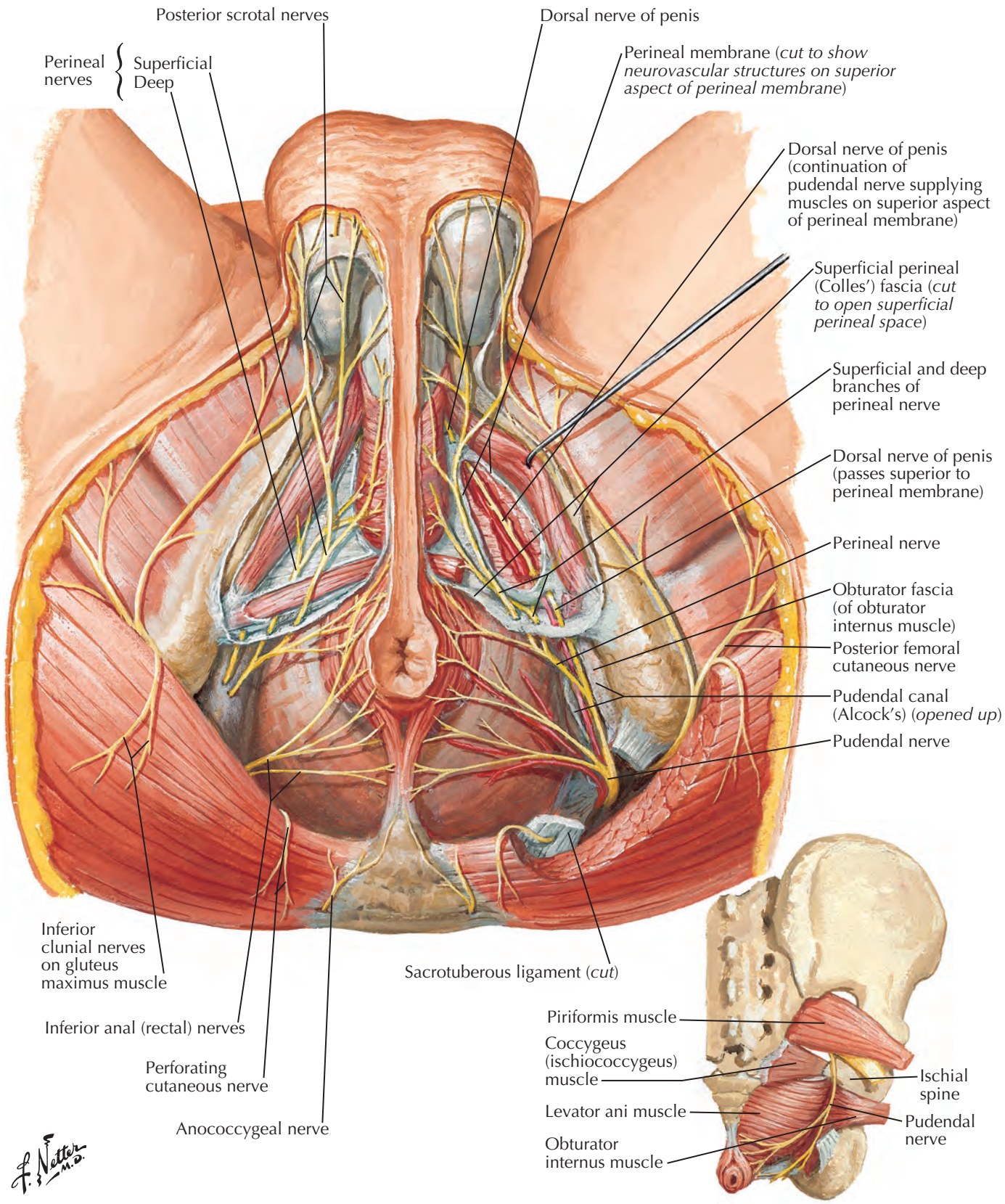


Lymphatic drainage from prostate

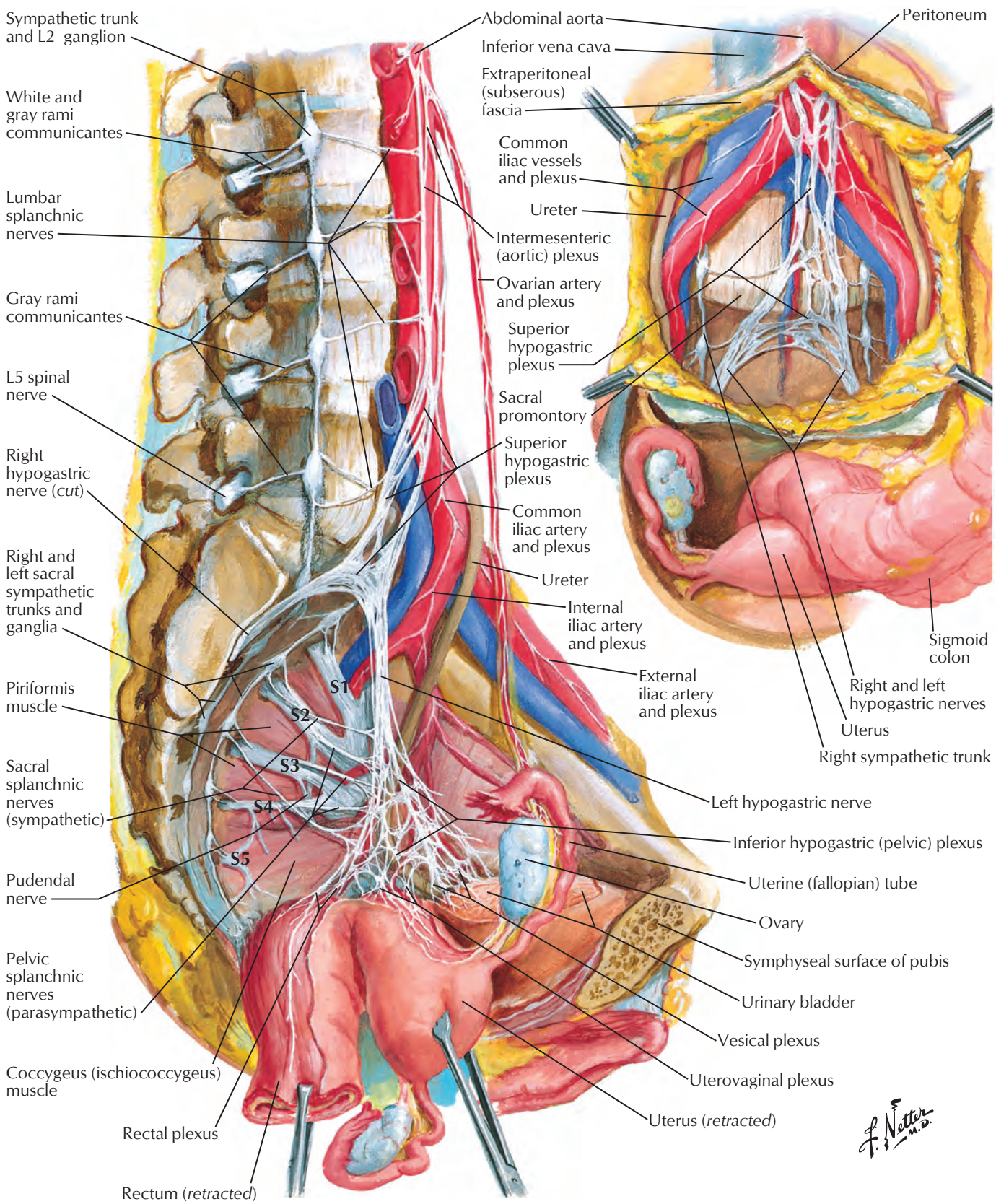

Splanchnic nerves
Greater
Lesser
Least
Subcostal nerve (T12)
Iliohypogastric nerve
Ilio-inguinal nerve
Sympathetic trunk and ganglia
Genitofemoral nerve
Lateral femoral cutaneous nerve
Femoral branch and Genital branch of genitofemoral nerve
Femoral nerve
Lateral femoral cutaneous nerve
Femoral branches of genitofemoral nerve
Anterior cutaneous branches of femoral nerve
Anterior cutaneous branch of iliohypogastric nerve
Genital branch of genitofemoral nerve
Anterior scrotal nerve (from ilio-inguinal nerve)
Celiac ganglia
Superior mesenteric ganglion
Aorticorenal ganglia
Lumbar splanchnic nerves
Inferior mesenteric ganglion
Testicular artery and plexus
Superior hypogastric plexus
Hypogastric nerves
Inferior hypogastric (pelvic) plexus
Ductus deferens and plexus
Femoral nerve
Testicular artery and plexus
Dorsal nerves of penis

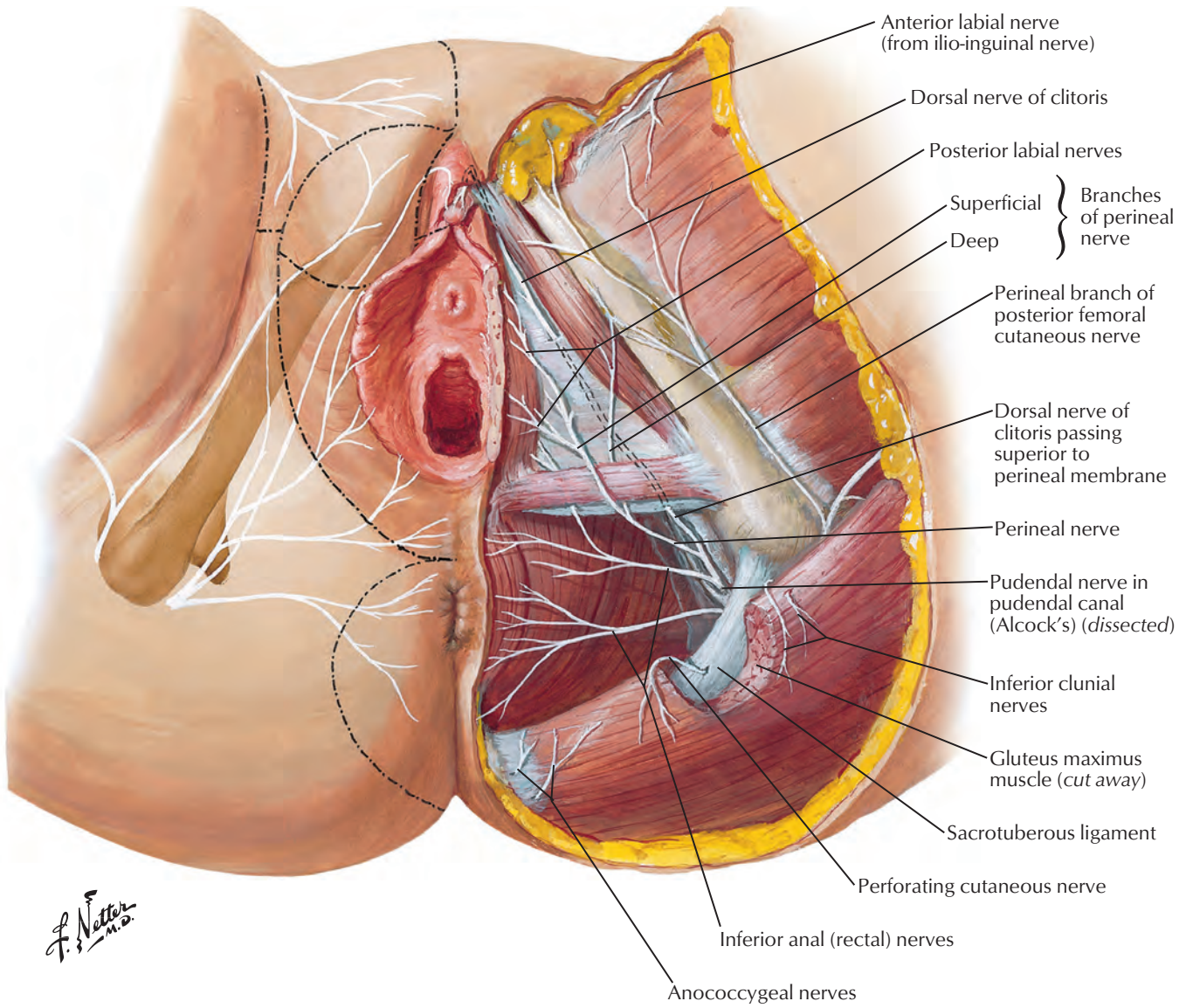
See also **Plate 297**




Posterior scrotal nerves
Dorsal nerve of penis
Perineal nerves
Superficial
Deep
Perineal membrane (*cut to show neurovascular structures on superior aspect of perineal membrane*)
Dorsal nerve of penis (continuation of pudendal nerve supplying muscles on superior aspect of perineal membrane)
Superficial perineal (Colles') fascia (*cut to open superficial perineal space*)
Superficial and deep branches of perineal nerve
Dorsal nerve of penis (passes superior to perineal membrane)
Perineal nerve
Obturator fascia (of obturator internus muscle)
Posterior femoral cutaneous nerve
Pudendal canal (Alcock's) (*opened up*)
Pudendal nerve
Inferior clunial nerves on gluteus maximus muscle
Sacrotuberous ligament (*cut*)
Inferior anal (rectal) nerves
Perforating cutaneous nerve
Anococcygeal nerve
Piriformis muscle
Coccygeus (ischiococcygeus) muscle
Levator ani muscle
Obturator internus muscle
Ischial spine
Pudendal nerve

See also **Plate 297**




Anterior labial nerve (from ilio-inguinal nerve)
Dorsal nerve of clitoris
Posterior labial nerves
Superficial
Deep
Branches of perineal nerve
Perineal branch of posterior femoral cutaneous nerve
Dorsal nerve of clitoris passing superior to perineal membrane
Perineal nerve
Pudendal nerve in pudendal canal (Alcock's) (*dissected*)
Inferior clunial nerves
Gluteus maximus muscle (*cut away*)
Sacrotuberous ligament
Perforating cutaneous nerve
Inferior anal (rectal) nerves
Anococcygeal nerves
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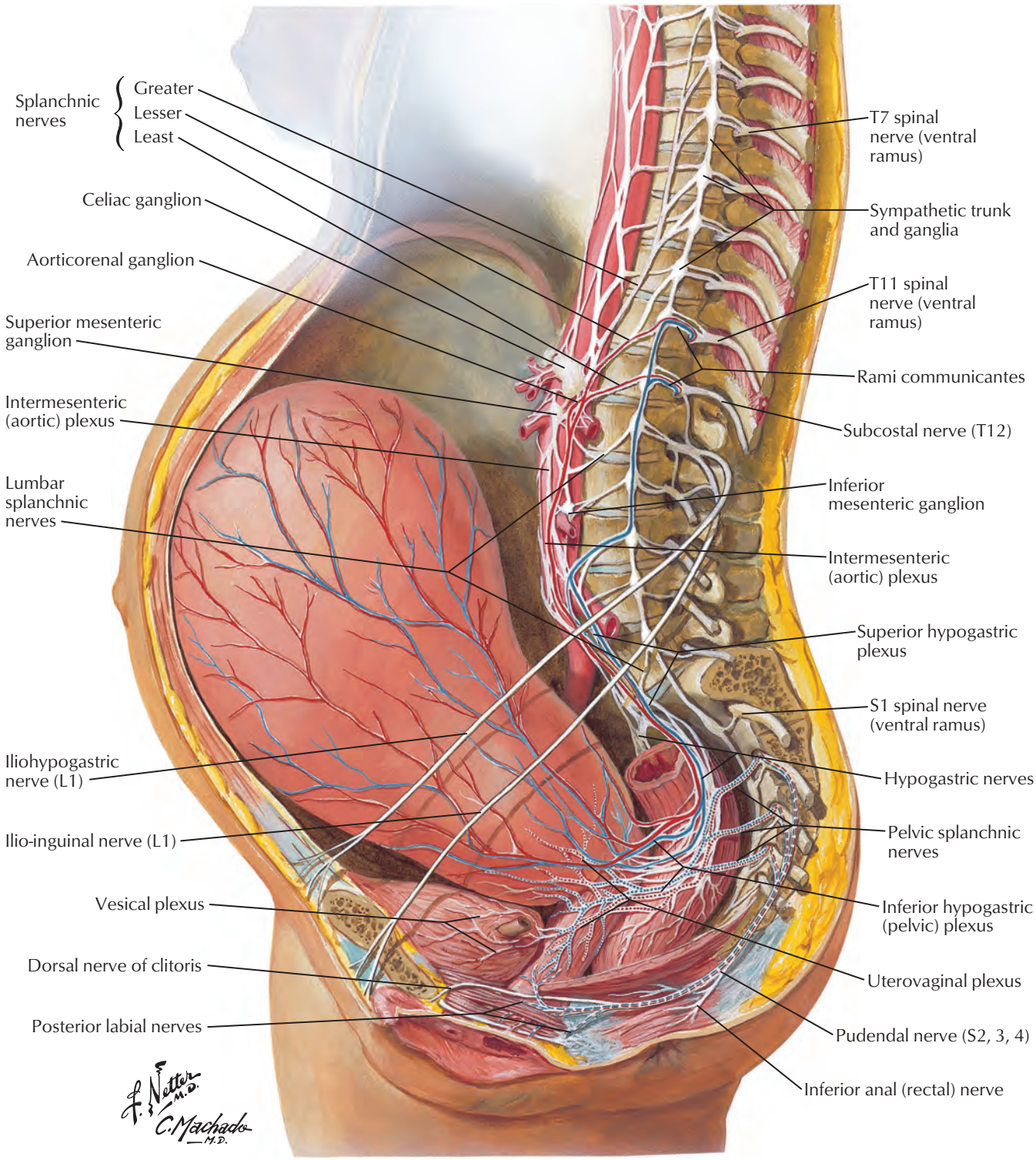


Sensory fibers from uterine body and fundus accompany sympathetic fibers via hypogastric plexuses to T11, 12 (L1?)

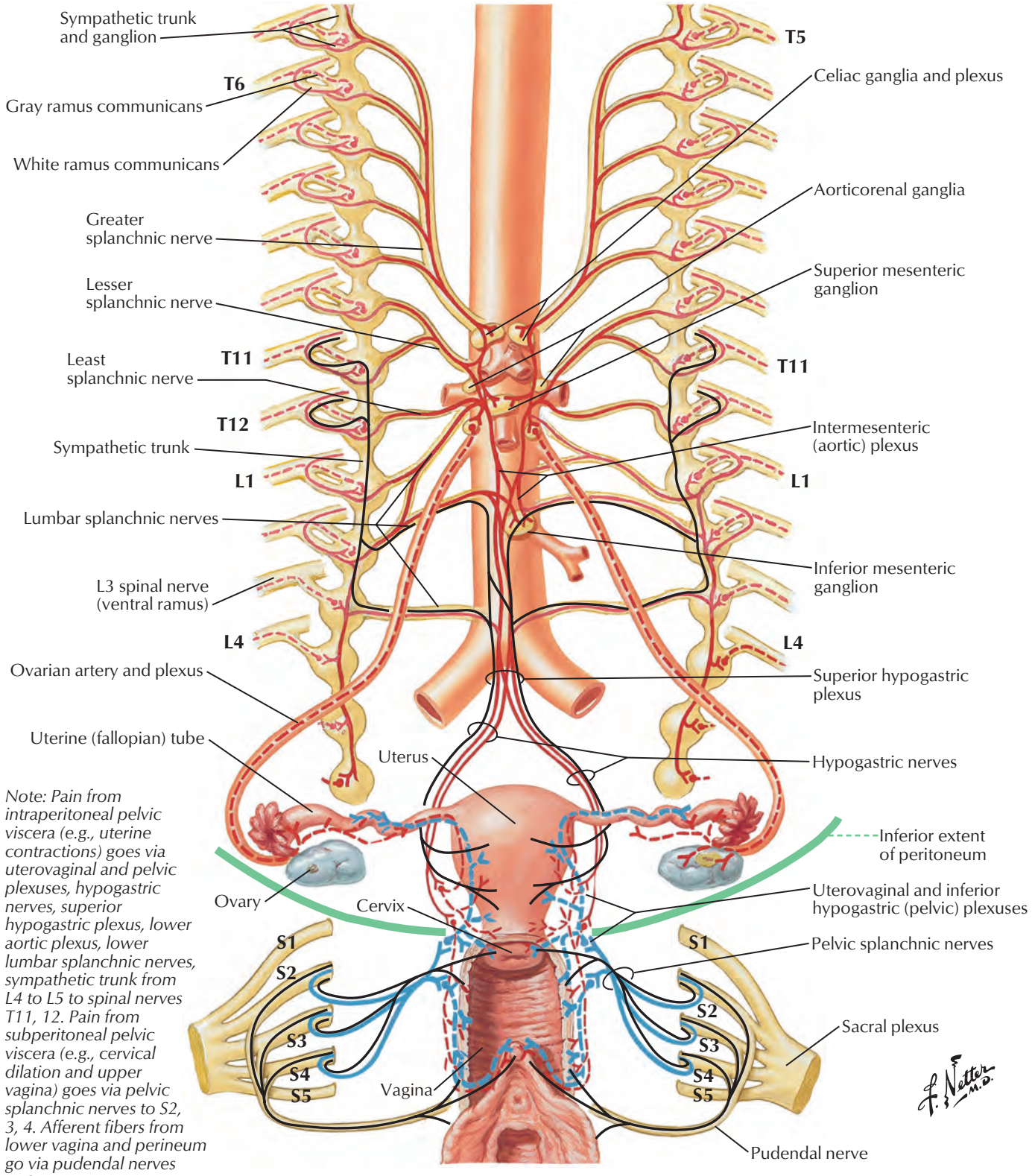
Motor fibers to uterine body and fundus (sympathetic)

Sensory fibers from cervix and upper vagina accompany pelvic splanchnic nerves (parasympathetic) to S2, 3, 4

Motor fibers to lower uterine segment, cervix, and upper vagina (parasympathetic)

Sensory fibers from lower vagina and perineum accompany somatic fibers via pudendal nerve to S2, 3, 4

Motor fibers to lower vagina and perineum via pudendal nerve (somatic)



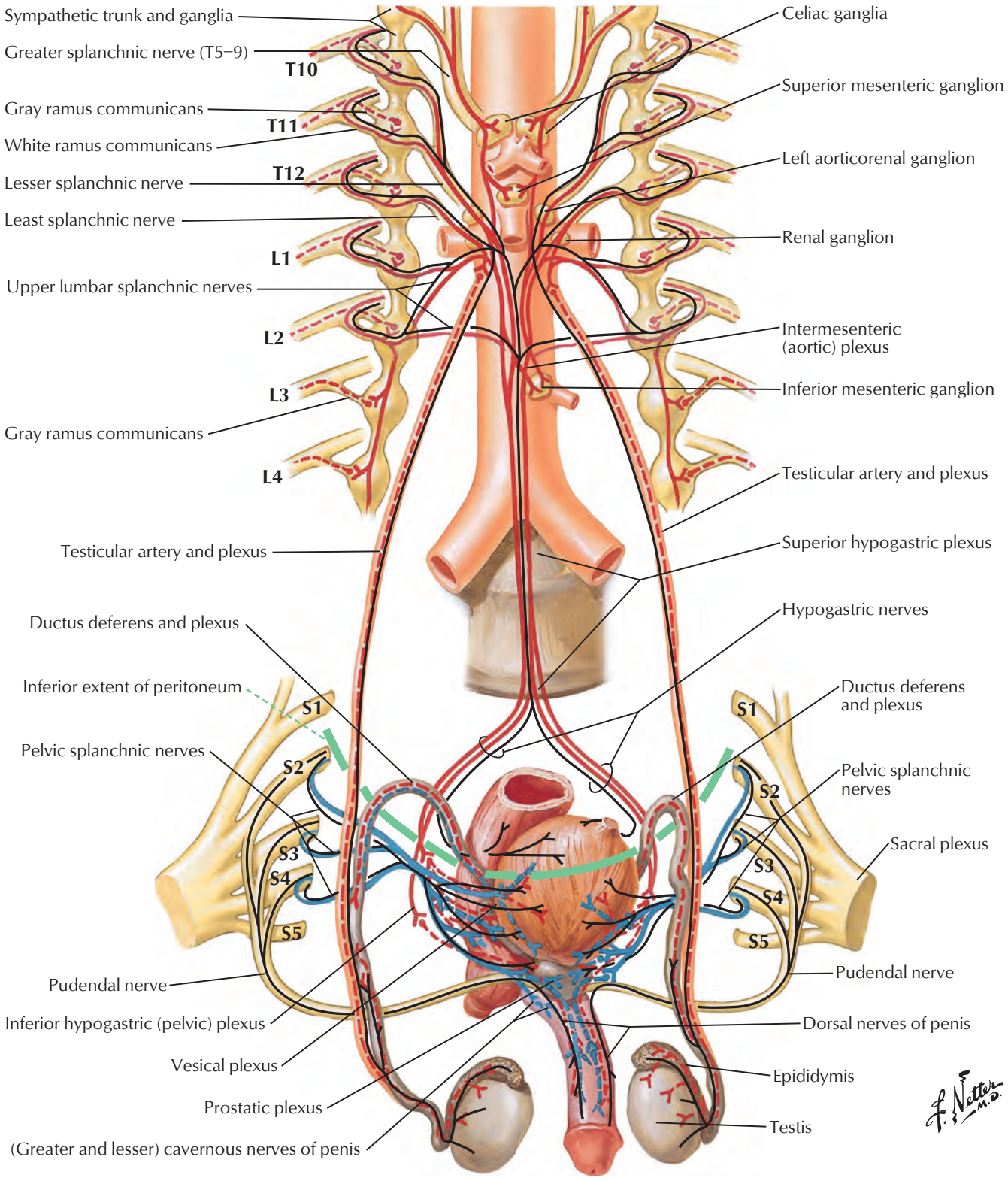
Note: Pain from intraperitoneal pelvic viscera (e.g., uterine contractions) goes via uterovaginal and pelvic plexuses, hypogastric nerves, superior hypogastric plexus, lower aortic plexus, lower lumbar splanchnic nerves, sympathetic trunk from L4 to L5 to spinal nerves T11, 12. Pain from subperitoneal pelvic viscera (e.g., cervical dilation and upper vagina) goes via pelvic splanchnic nerves to S2, 3, 4. Afferent fibers from lower vagina and perineum go via pudendal nerves to S2, 3, 4.

Sympathetic fibers { **Preganglionic** ——— **Postganglionic** - - - -

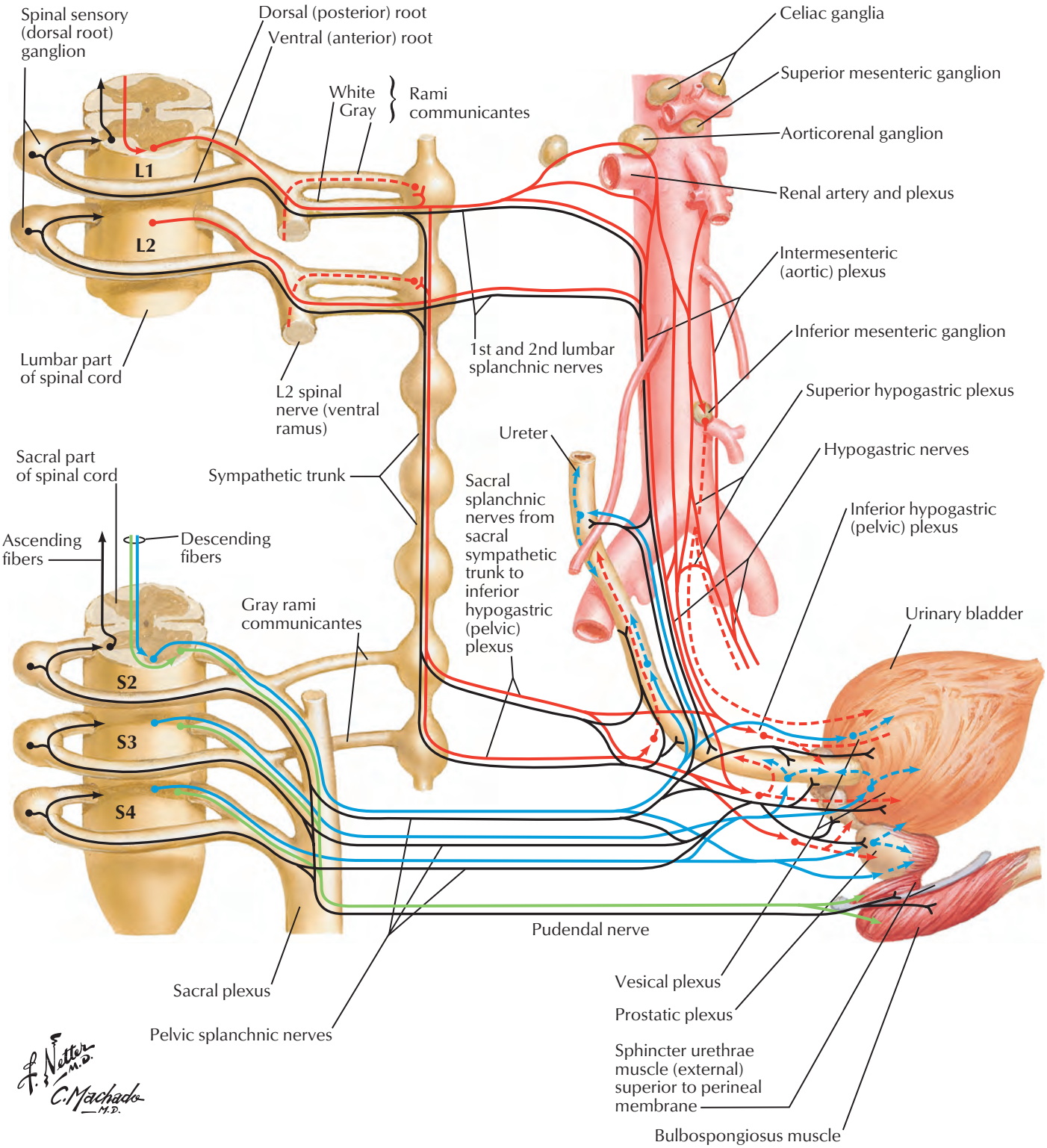
Parasympathetic fibers { **Preganglionic** ——— **Postganglionic** - - - -

Afferent fibers ———

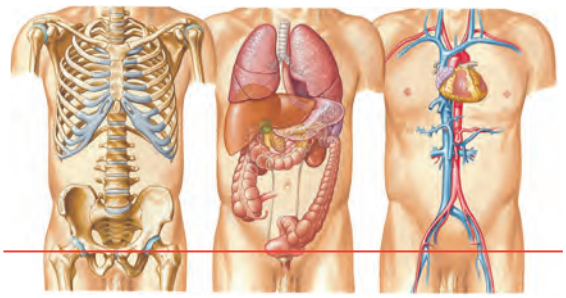
Innervation of Male Reproductive Organs: Schema

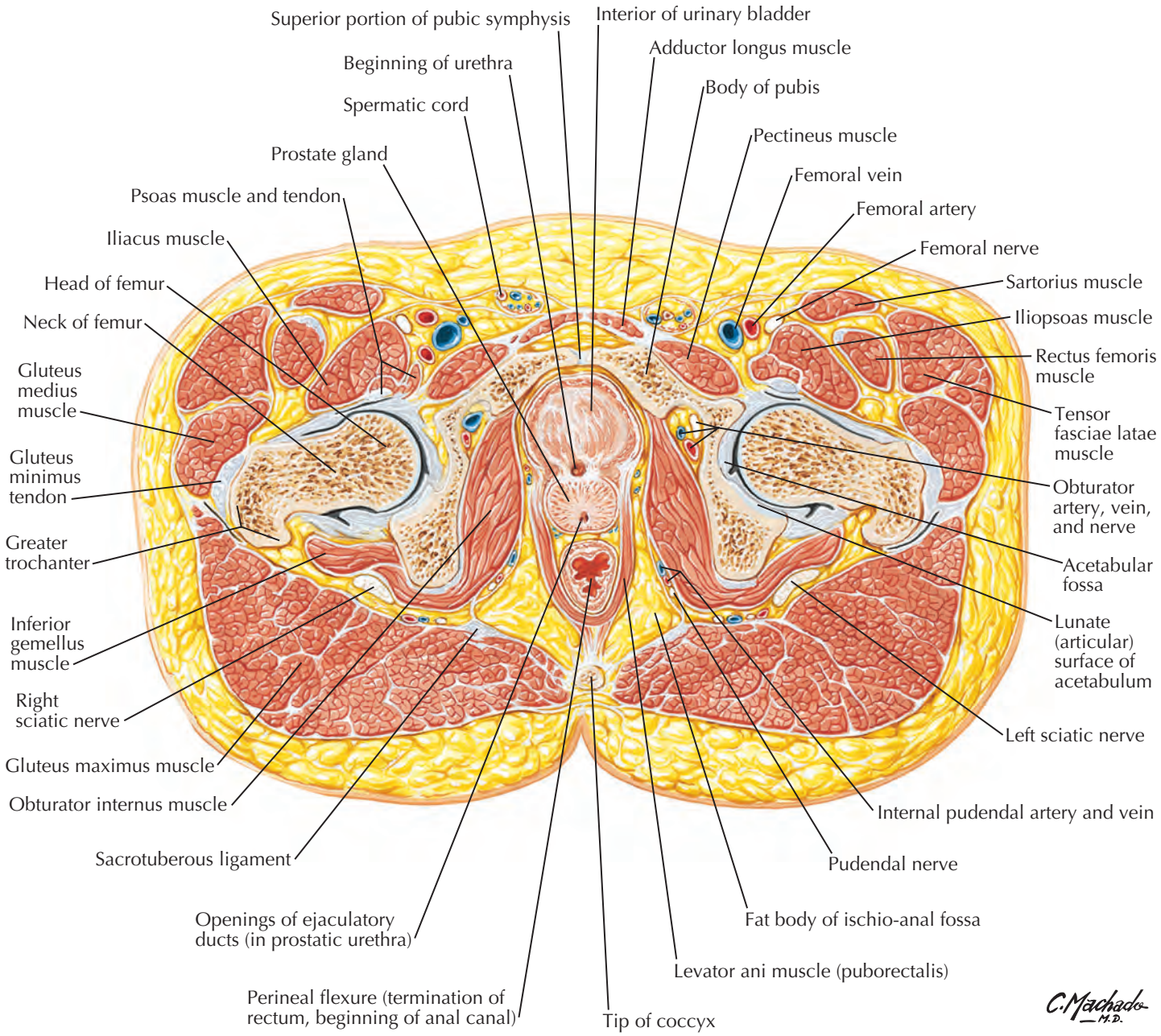


Innervation of Urinary Bladder and Lower Ureter: Schema

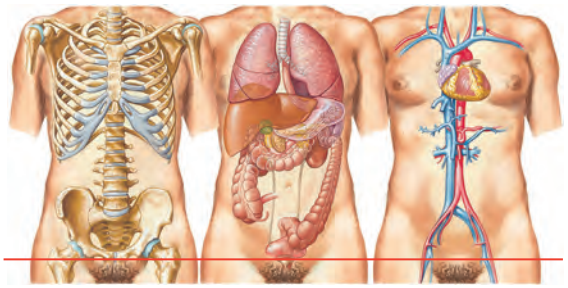


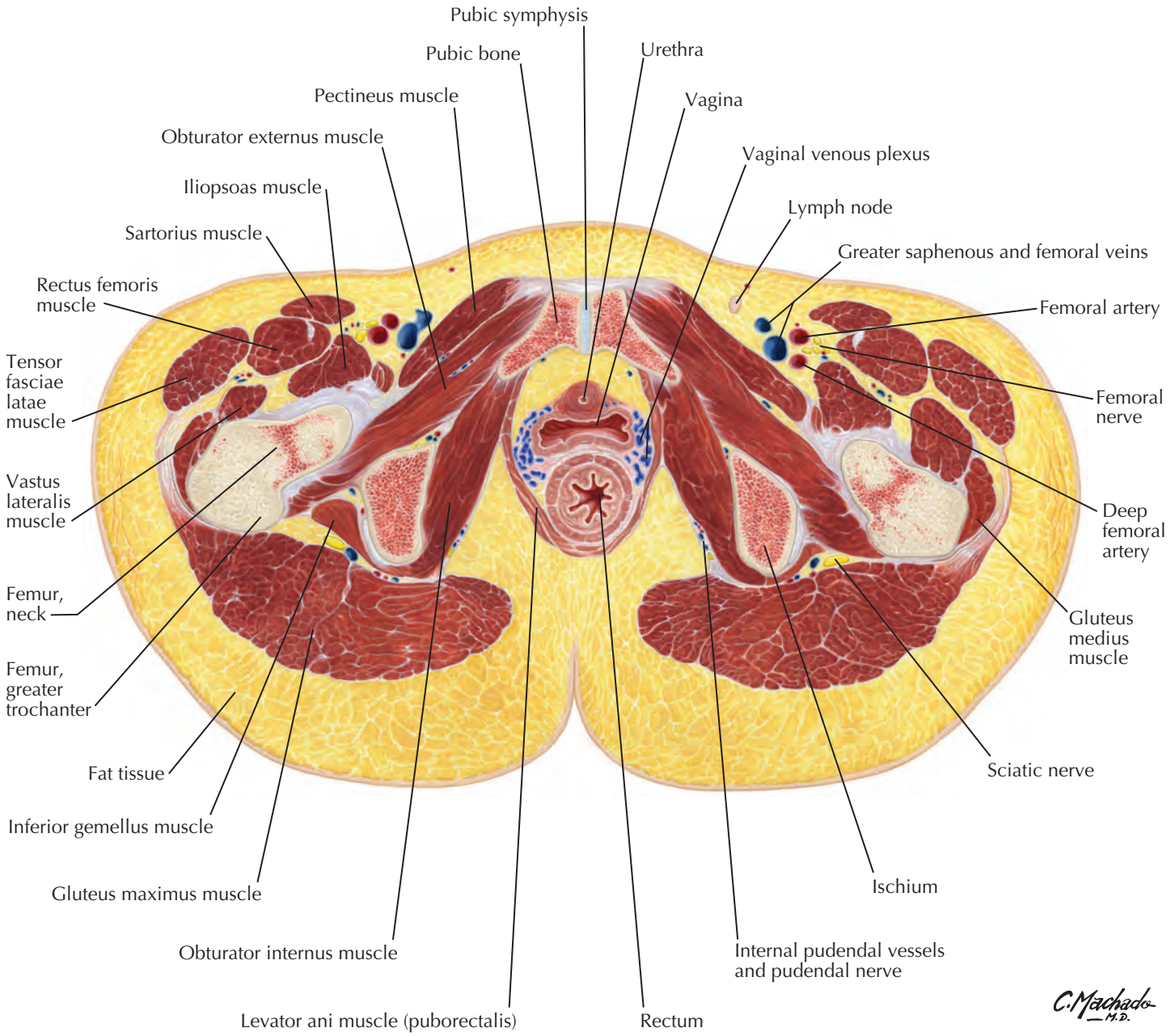
Male Pelvis: Cross Section of Bladder-Prostate Junction





Female Pelvis: Cross Section of Vagina-Urethra

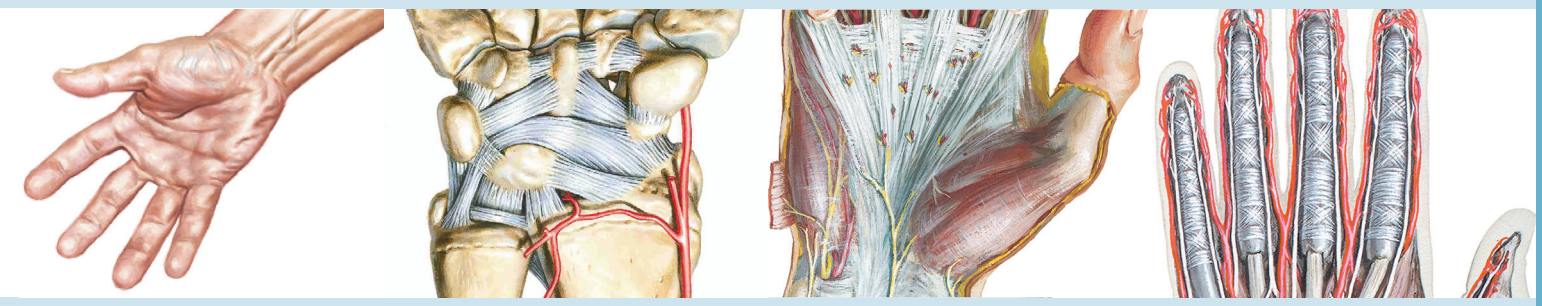




MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Bulbospongiosus	*Male:* median raphe, bulb of penis, perineal body *Female:* perineal body	*Male:* perineal membrane, corpus cavernosum, bulb of penis *Female:* dorsum of clitoris, inferior fascia of urogenital diaphragm, bulb of vestibule, pubic arch	Deep branch of perineal nerve from pudendal nerve	*Male:* compresses bulb of penis, forces blood into body of penis during erection, removes urine from urethra and semen during ejaculation *Female:* constricts vaginal orifice, assists in expressing secretions of greater vestibular gland, forces blood into body of clitoris	Internal pudendal artery and its branch (perineal artery)	Perineal
Coccygeus (ischiococcygeus)	Ischial spine, sacrospinous ligament	Inferior sacrum, coccyx	Ventral rami of lower sacral nerves	Supports pelvic viscera, draws coccyx forward	Inferior gluteal artery	Pelvic floor
Compressor urethrae (female only)	Ischiopubic ramus	Anterior aspect of urethra	Perineal branches of pudendal nerve	Sphincter of urethra	Perineal branch of internal pudendal artery	Perineal
Cremaster	Lower edge of internal oblique and middle of inguinal ligament	Pubic tubercle, crest of pubis	Genital branch of genitofemoral nerve	Retracts testicle	Cremasteric branch of inferior epigastric artery	Spermatic cord
Deep transverse perineal	Inner surface of inferior ischial rami	*Male:* medial tendinous raphe and perineal body *Female:* sides of vagina	Perineal branches of pudendal nerve	Stabilizes perineal body, supports prostate/vagina	Perineal branch of internal pudendal artery	Perineal
External anal sphincter	Tip of coccyx, anococcygeal ligament	Deeper fibers surround anal canal, attach posteriorly to coccyx and anteriorly to central point of perineum	Perineal and inferior rectal branches of pudendal nerve	Closes anal orifice	Inferior rectal and transverse perineal artery	Perineal
Iliacus	Superior 2/3 of iliac fossa, ala of sacrum, anterior sacro-iliac ligaments	Lesser trochanter of femur and shaft inferior to it, to psoas major tendon	Femoral nerve	Flexes thigh at hips and stabilizes hip joint, acts with psoas major	Iliac branches of iliolumbar artery	Anterior thigh
Ischiocavernosus	Inferior internal surface of ischiopubic ramus, ischial tuberosity	Crus of penis or clitoris	Deep branch of perineal nerve from pudendal nerve	Forces blood into body of penis and clitoris during erection	Internal pudendal artery and its branch (perineal artery)	Perineal
Levator ani	Body of pubis, tendinous arch of obturator fascia, ischial spine	Perineal body, coccyx, anococcygeal raphe, walls of prostate or vagina, rectum, anal canal	Ventral rami of lower sacral nerves, perineal nerve	Supports pelvic viscera, raises pelvic floor	Inferior gluteal artery, internal pudendal artery and its branches (inferior rectal and perineal arteries)	Pelvic floor
Obturator internus	Pelvic surface of obturator membrane and surrounding bone	Medial surface of greater trochanter of femur	Nerve to obturator internus	Laterally rotates extended thigh, abducts flexed thigh at hip	Internal pudendal and obturator arteries	Gluteal region

Variations in spinal nerve contributions to the innervation of muscles, their arterial supply, their attachments, and their actions are common themes in human anatomy. Therefore, expect differences between texts and realize that anatomical variation is normal.

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Piriformis	Anterior surface of sacral segments 2–4, sacrotuberous ligament	Superior border of greater trochanter of femur	Ventral rami of L5, S1, S2	Laterally rotates extended thigh, abducts flexed thigh at hip	Superior and inferior gluteal arteries, internal pudendal artery	Gluteal region
Puborectalis	Lower part of pubic symphysis, superior fascia of urogenital diaphragm	Loops around rectum; no distal attachment	Nerve to levator ani muscle			Pelvic floor
Sphincter urethrae	External fibers from junction of inferior pubic and ischial rami and adjacent fascia; internal fibers pass medially to surround membranous urethra	*Male:* median raphe in front and behind urethra *Female:* encloses urethra, attaches to sides of vagina	Perineal branches of pudendal nerve	Compresses urethra at end of micturition; in female also compresses the distal vagina	Perineal branch of internal pudendal artery	Perineal
Sphincter urethrovaginalis (female only)	Perineal body	Passes forward and anterior around urethra	Perineal branches of pudendal nerve	Sphincter of urethra and vagina	Perineal branch of pudendal artery	Perineal
Superficial transverse perineal	Ischial rami and tuberosities	Central tendon (perineal body)	Perineal branches of pudendal nerve	Stabilizes central tendon	Perineal branch of internal pudendal artery	Perineal



Section

6 UPPER LIMB

Topographic Anatomy

Plate 398

398 Upper Limb: Surface Anatomy

Cutaneous Anatomy

Plates 399–403

399 Dermatomes of Upper Limb

400 Cutaneous Innervation of Upper Limb

401 Cutaneous Nerves and Superficial Veins of Shoulder and Arm

402 Cutaneous Nerves and Superficial Veins of Forearm

403 Lymph Vessels and Nodes of Upper Limb

Shoulder and Axilla

Plates 404–416

404 Clavicle and Sternoclavicular Joint

405 Humerus and Scapula: Anterior Views

406 Humerus and Scapula: Posterior View

407 Shoulder: Anteroposterior Radiograph

408 Shoulder (Glenohumeral Joint)

409 Muscles of Shoulder

410 Axilla: Posterior Wall

411 Muscles of Rotator Cuff

412 Pectoral, Clavipectoral, and Axillary Fasciae

413 Scapulothoracic and Scapulohumeral Dissection

414 Axillary Artery and Anastomoses around Scapula

415 Axilla (Dissection): Anterior View
416 Brachial Plexus: Schema

Arm

Plates 417–421

417 Muscles of Arm: Anterior Views
418 Muscles of Arm: Posterior Views
419 Brachial Artery in Situ
420 Arteries of Arm and Proximal Forearm
421 Arm: Serial Cross Sections

Elbow and Forearm

Plates 422–438

422 Bones of Elbow
423 Elbow: Radiographs
424 Ligaments of Elbow
425 Bones of Forearm
426 Individual Muscles of Forearm: Rotators of Radius
427 Individual Muscles of Forearm: Extensors of Wrist and Digits
428 Individual Muscles of Forearm: Flexors of Wrist
429 Individual Muscles of Forearm: Flexors of Digits
430 Muscles of Forearm (Superficial Layer): Posterior View
431 Muscles of Forearm (Deep Layer): Posterior View
432 Muscles of Forearm (Superficial Layer): Anterior View
433 Muscles of Forearm (Intermediate Layer): Anterior View
434 Muscles of Forearm (Deep Layer): Anterior View
435 Arteries of Forearm
436 Forearm: Serial Cross Sections, Anterior View
437 Attachments of Muscles of Forearm: Anterior View
438 Attachments of Muscles of Forearm: Posterior View

Wrist and Hand

Plates 439–458

439 Carpal Bones
440 Movements of Wrist
441 Ligaments of Wrist
442 Ligaments of Wrist (continued)
443 Bones of Wrist and Hand
444 Wrist and Hand: Radiographs
445 Metacarpophalangeal and Interphalangeal Ligaments
446 Wrist and Hand: Superficial Palmar Dissections
447 Wrist and Hand: Deeper Palmar Dissections
448 Lumbrical Muscles and Bursae, Spaces, and Sheaths: Schema
449 Flexor Tendons, Arteries, and Nerves at Wrist
450 Bursae, Spaces, and Tendon Sheaths of Hand
451 Flexor and Extensor Tendons in Fingers
452 Intrinsic Muscles of Hand
453 Arteries and Nerves of Hand: Palmar Views
454 Wrist and Hand: Superficial Radial Dissection
455 Wrist and Hand: Superficial Dorsal Dissection
456 Wrist and Hand: Deep Dorsal Dissection
457 Extensor Tendons at Wrist
458 Fingers

Neurovasculature

Plates 459–466

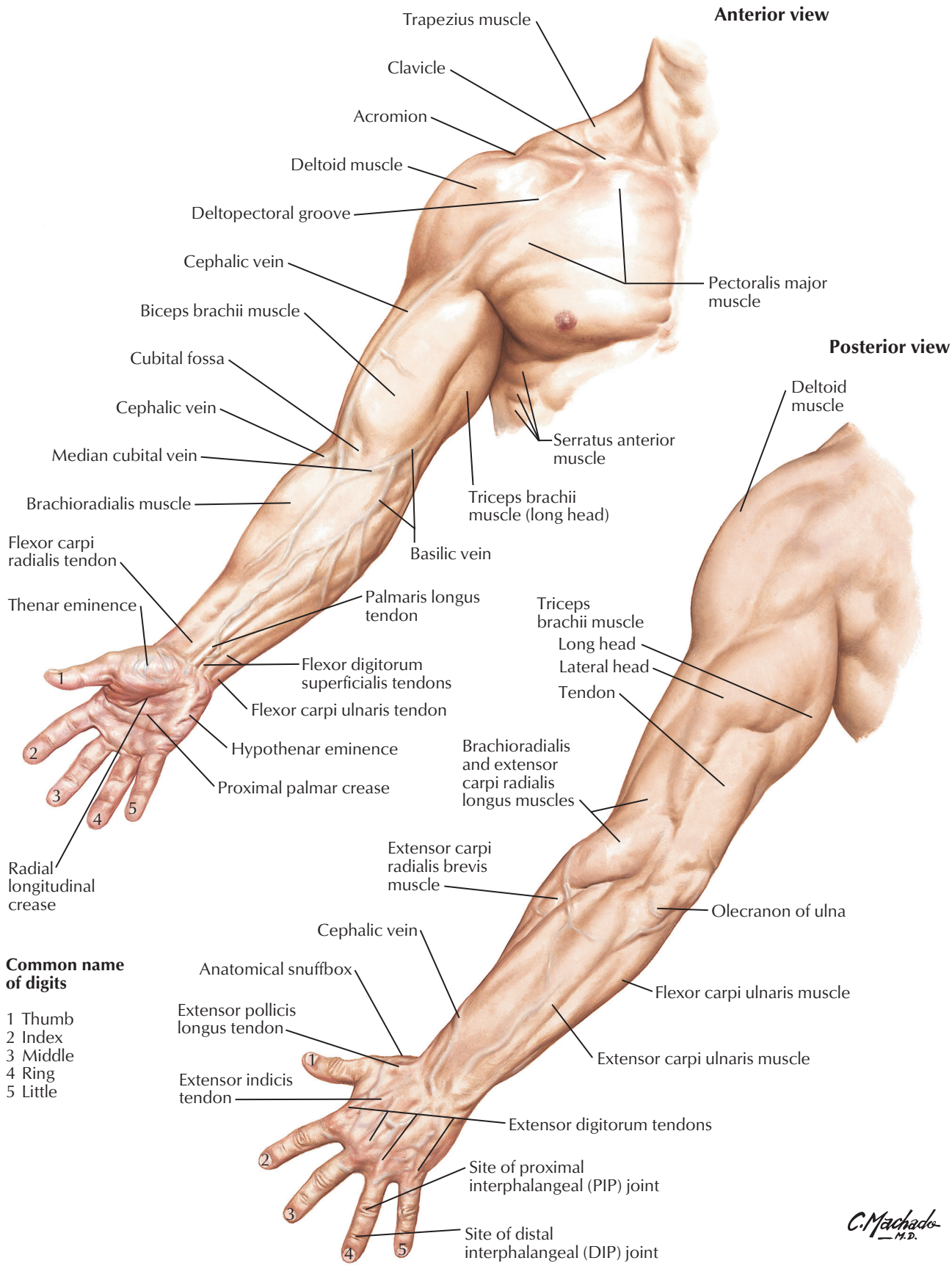
459 Cutaneous Innervation of Wrist and Hand
460 Arteries and Nerves of Upper Limb
461 Nerves of Upper Limb
462 Musculocutaneous Nerve
463 Median Nerve
464 Ulnar Nerve
465 Radial Nerve in Arm and Nerves of Posterior Shoulder
466 Radial Nerve in Forearm

Regional Scans

Plate 467

467 Shoulder MRI, CT Scan, and Arthrogram

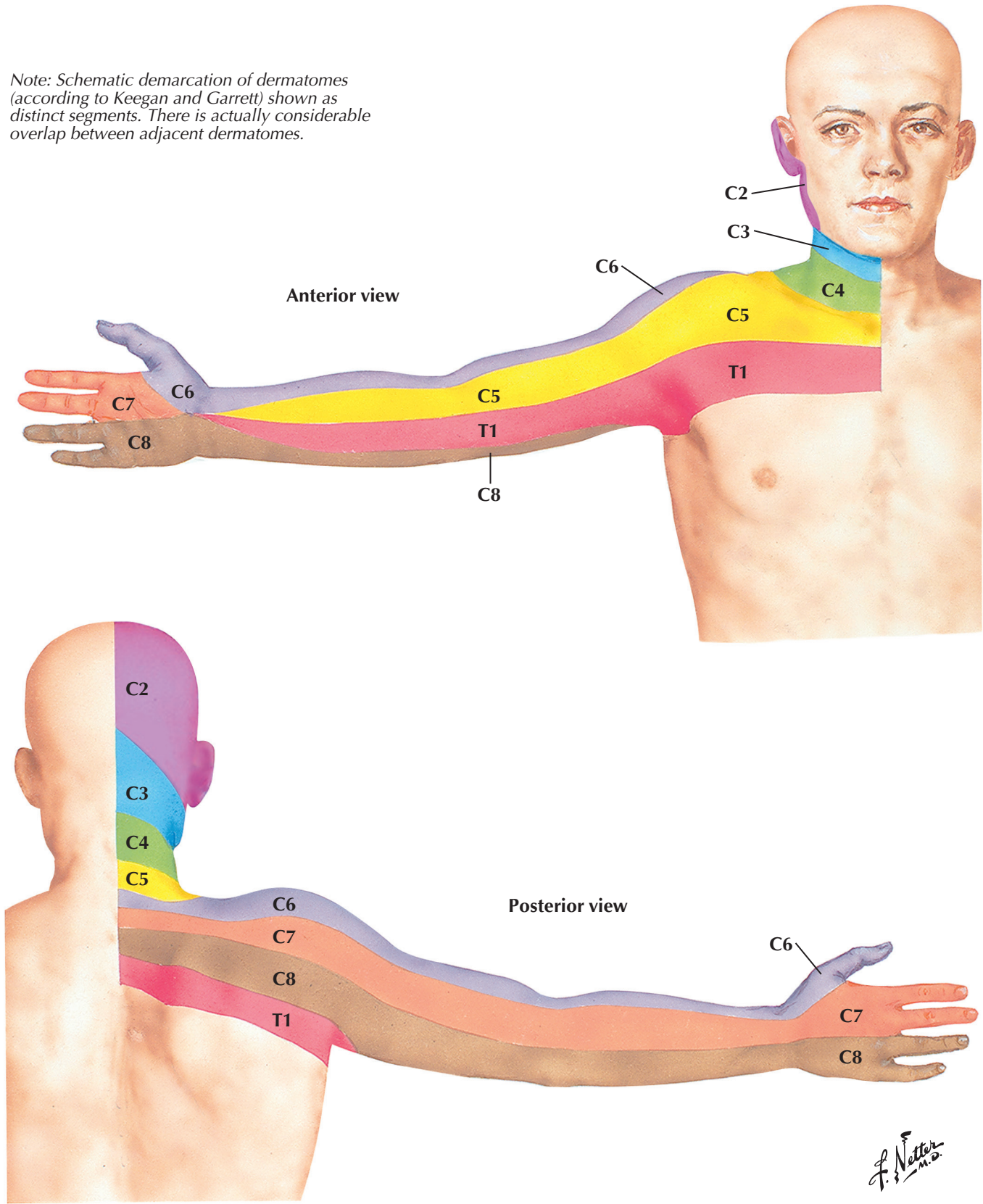
Muscle Tables

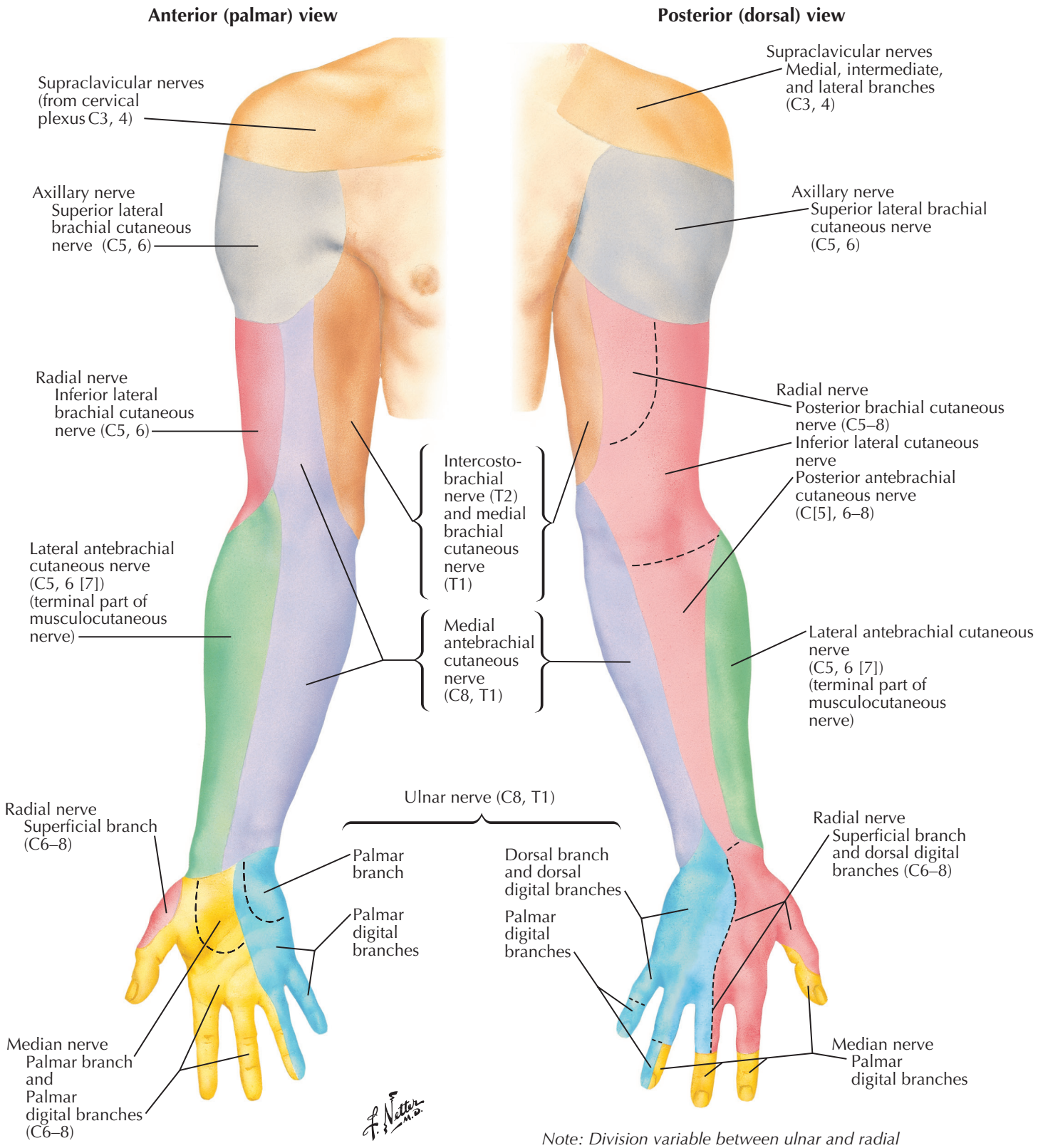

Anterior view
Trapezius muscle
Clavicle
Acromion
Deltoid muscle
Deltopectoral groove
Cephalic vein
Biceps brachii muscle
Cubital fossa
Cephalic vein
Median cubital vein
Brachioradialis muscle
Flexor carpi radialis tendon
Thenar eminence
Palmaris longus tendon
Flexor digitorum superficialis tendons
Flexor carpi ulnaris tendon
Hypothenar eminence
Proximal palmar crease
Radial longitudinal crease
Pectoralis major muscle
Serratus anterior muscle
Triceps brachii muscle (long head)
Basilic vein
Posterior view
Deltoid muscle
Triceps brachii muscle
Long head
Lateral head
Tendon
Brachioradialis and extensor carpi radialis longus muscles
Extensor carpi radialis brevis muscle
Olecranon of ulna
Cephalic vein
Anatomical snuffbox
Extensor pollicis longus tendon
Extensor indicis tendon
Flexor carpi ulnaris muscle
Extensor carpi ulnaris muscle
Extensor digitorum tendons
Site of proximal interphalangeal (PIP) joint
Site of distal interphalangeal (DIP) joint
1
2
3
4
5
Common name of digits
1 Thumb
2 Index
3 Middle
4 Ring
5 Little
C. Machado M.D.

Dermatomes of Upper Limb

See also **Plate 162**

Note: Schematic demarcation of dermatomes (according to Keegan and Garrett) shown as distinct segments. There is actually considerable overlap between adjacent dermatomes.

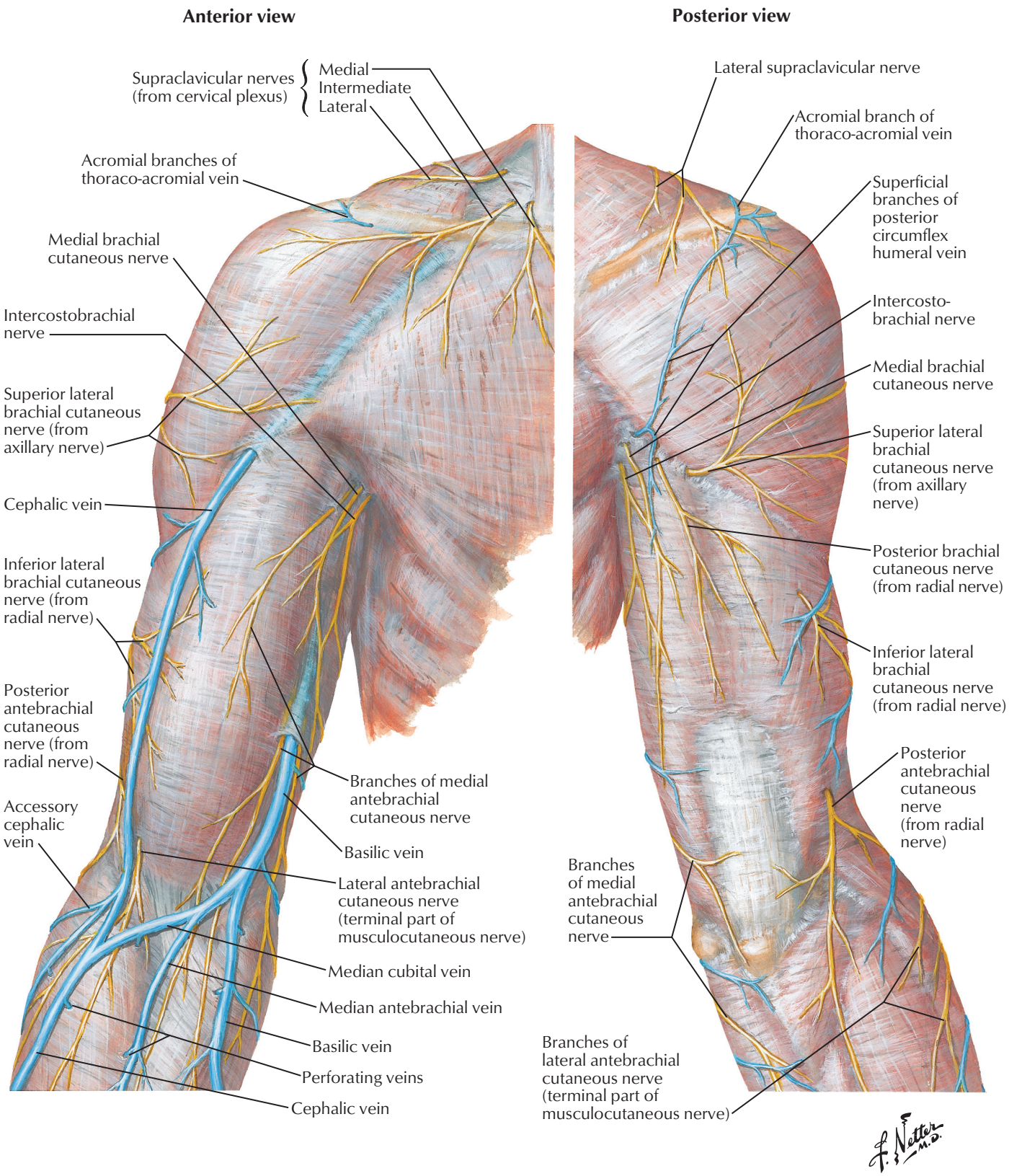


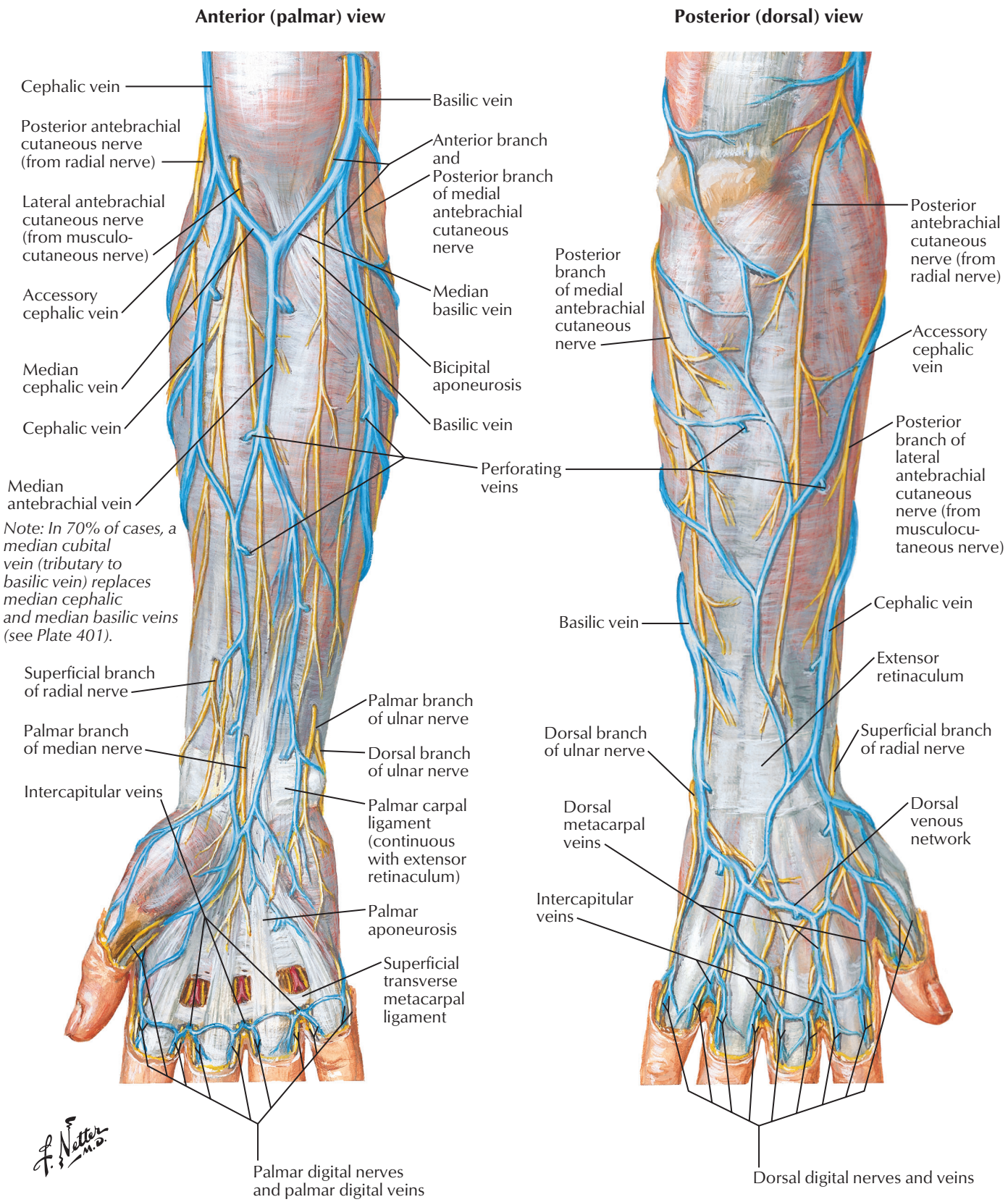


Note: Division variable between ulnar and radial innervation on dorsum of hand and often aligns with middle of 4th digit instead of 3rd digit as shown.

Cutaneous Nerves and Superficial Veins of Shoulder and Arm

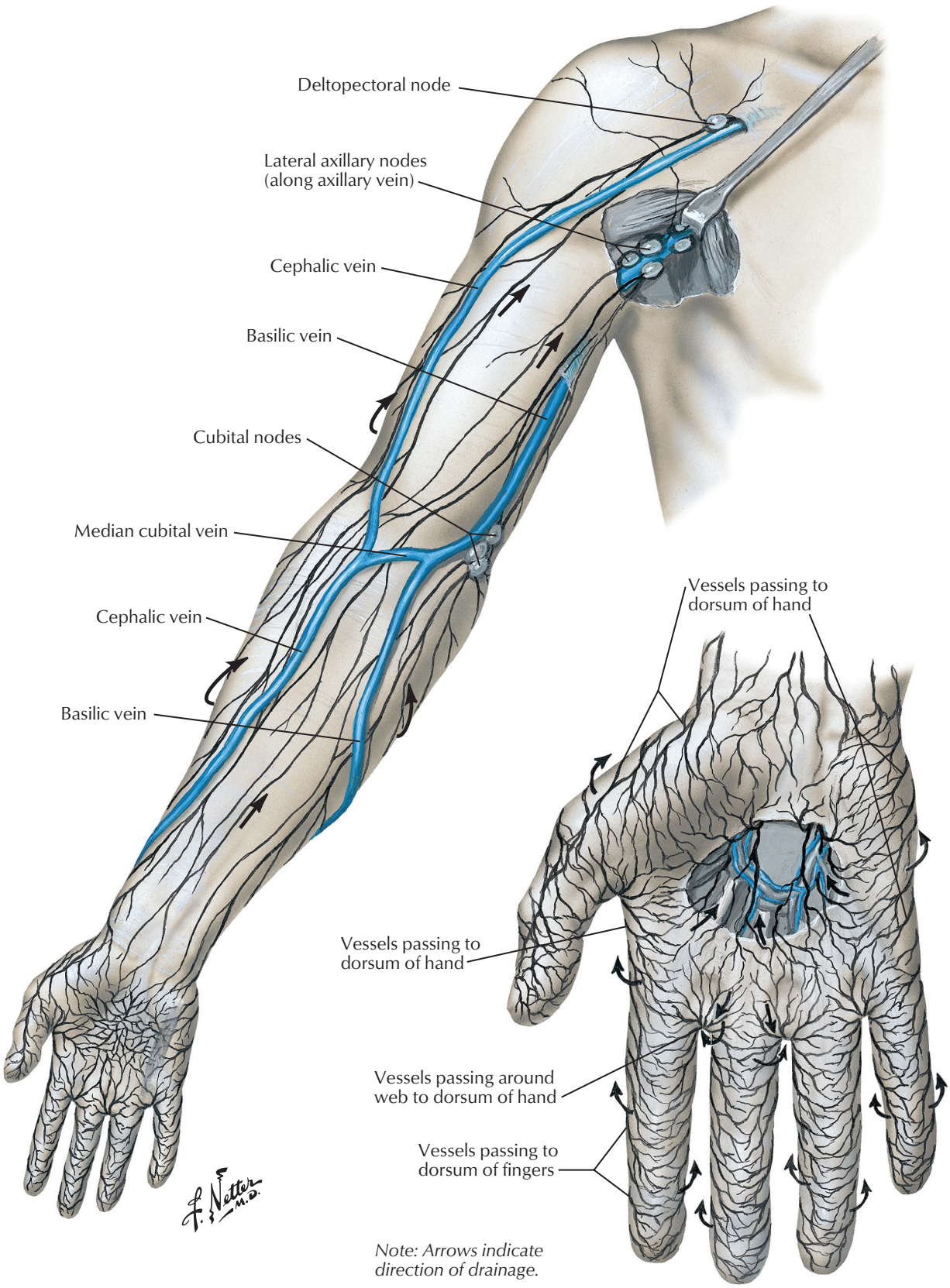
See also **Plates 252, 419**

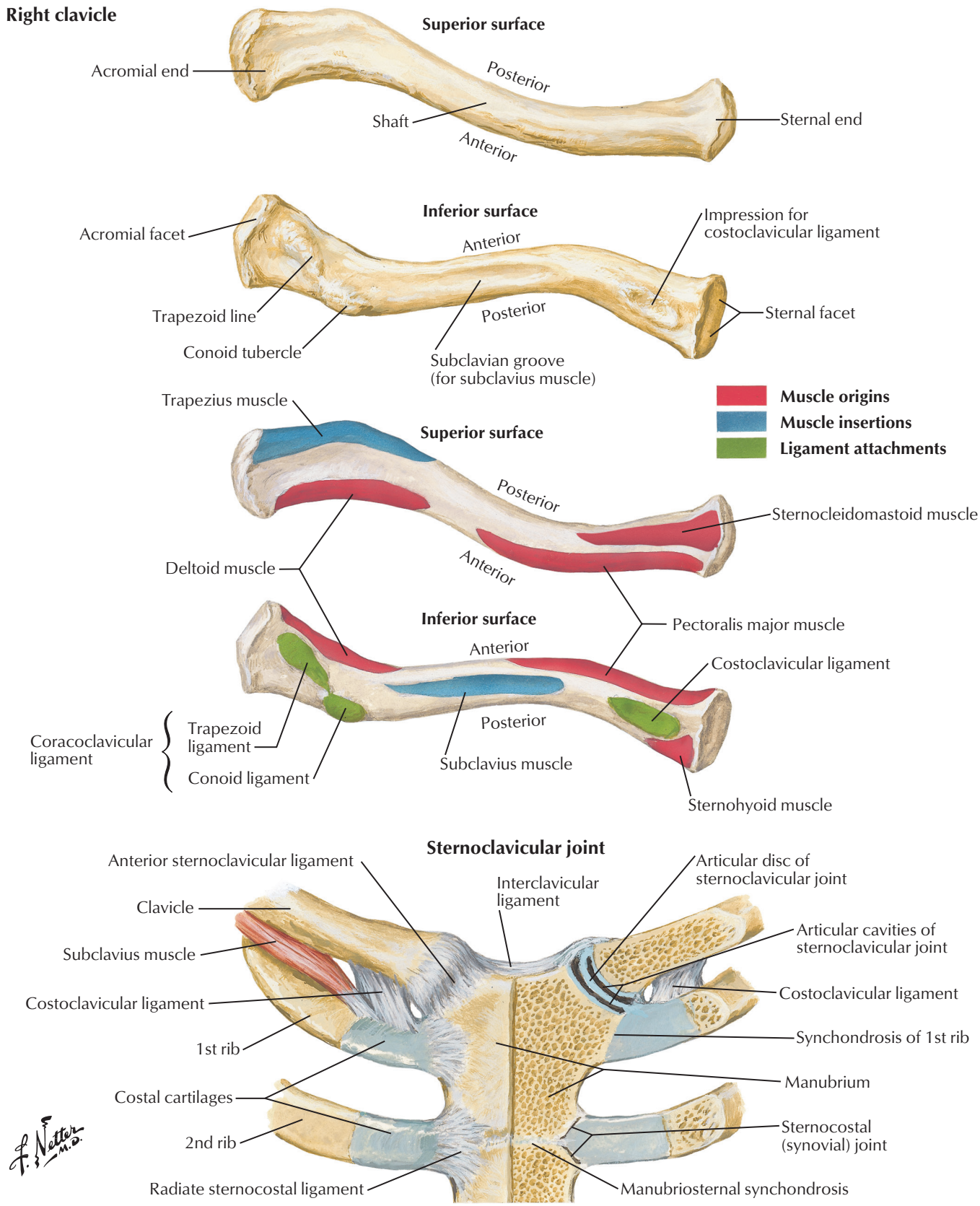



Anterior (palmar) view
Posterior (dorsal) view
Cephalic vein
Basilic vein
Posterior antebrachial cutaneous nerve (from radial nerve)
Anterior branch and Posterior branch of medial antebrachial cutaneous nerve
Lateral antebrachial cutaneous nerve (from musculo-cutaneous nerve)
Median basilic vein
Accessory cephalic vein
Bicipital aponeurosis
Median cephalic vein
Basilic vein
Cephalic vein
Perforating veins
Median antebrachial vein
Note: In 70% of cases, a median cubital vein (tributary to basilic vein) replaces median cephalic and median basilic veins (see Plate 401).
Superficial branch of radial nerve
Palmar branch of ulnar nerve
Palmar branch of median nerve
Dorsal branch of ulnar nerve
Intercapitular veins
Palmar carpal ligament (continuous with extensor retinaculum)
Palmar aponeurosis
Superficial transverse metacarpal ligament
Palmar digital nerves and palmar digital veins
Posterior branch of medial antebrachial cutaneous nerve
Posterior antebrachial cutaneous nerve (from radial nerve)
Accessory cephalic vein
Posterior branch of lateral antebrachial cutaneous nerve (from musculocu-taneous nerve)
Basilic vein
Cephalic vein
Extensor retinaculum
Dorsal branch of ulnar nerve
Superficial branch of radial nerve
Dorsal metacarpal veins
Dorsal venous network
Intercapitular veins
Dorsal digital nerves and veins

Lymph Vessels and Nodes of Upper Limb

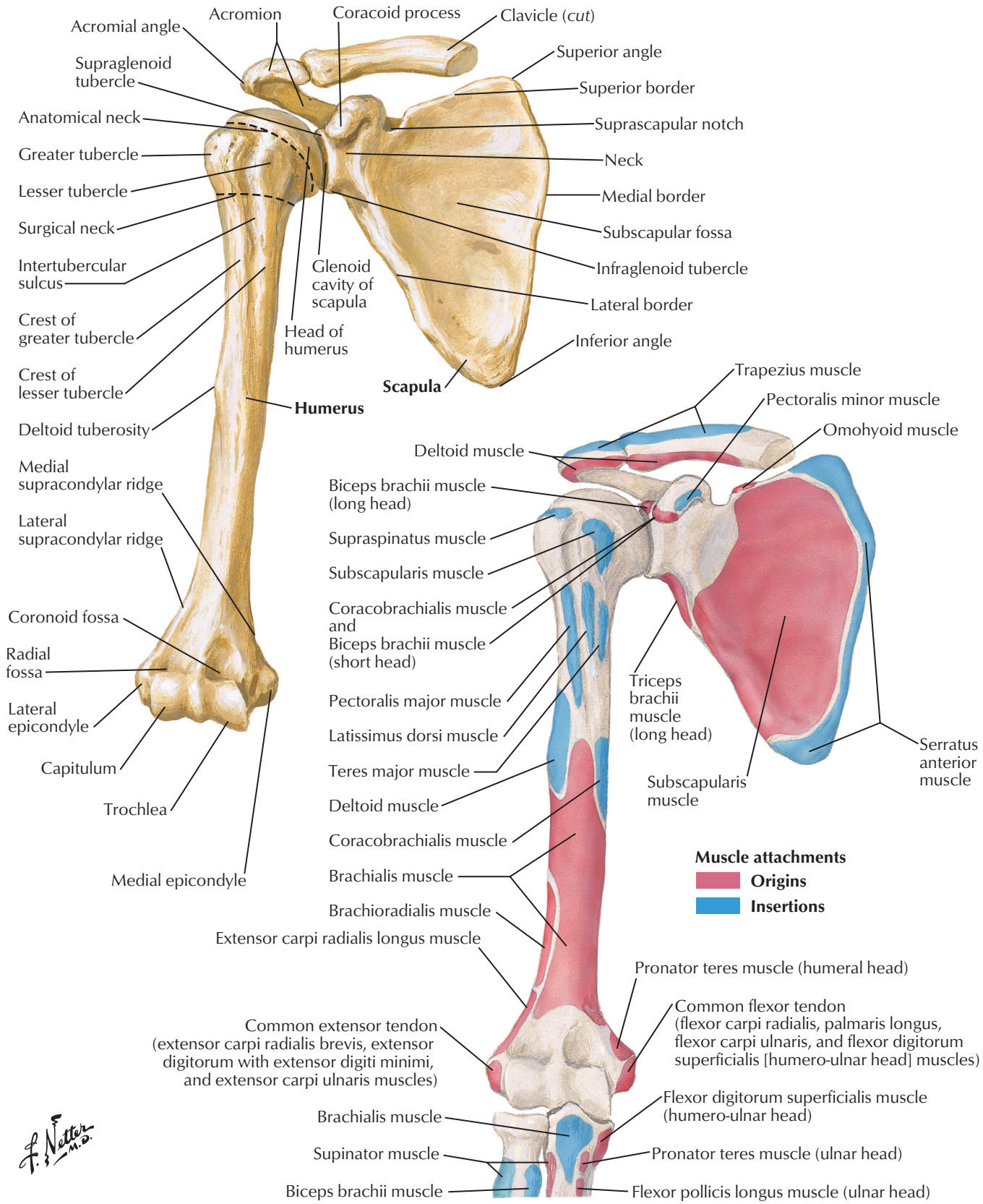
See also **Plates 181, 455**




Right clavicle
Superior surface
Acromial end
Posterior
Shaft
Sternal end
Anterior
Inferior surface
Acromial facet
Anterior
Impression for costoclavicular ligament
Trapezoid line
Posterior
Sternal facet
Conoid tubercle
Subclavian groove (for subclavius muscle)
Trapezius muscle
Muscle origins
Muscle insertions
Ligament attachments
Superior surface
Posterior
Sternocleidomastoid muscle
Deltoid muscle
Anterior
Inferior surface
Pectoralis major muscle
Anterior
Costoclavicular ligament
Coracoclavicular ligament
Trapezoid ligament
Posterior
Conoid ligament
Subclavius muscle
Sternohyoid muscle
Sternoclavicular joint
Anterior sternoclavicular ligament
Articular disc of sternoclavicular joint
Interclavicular ligament
Clavicle
Articular cavities of sternoclavicular joint
Subclavius muscle
Costoclavicular ligament
Costoclavicular ligament
Synchondrosis of 1st rib
1st rib
Manubrium
Costal cartilages
Sternocostal (synovial) joint
2nd rib
Radiate sternocostal ligament
Manubriosternal synchondrosis

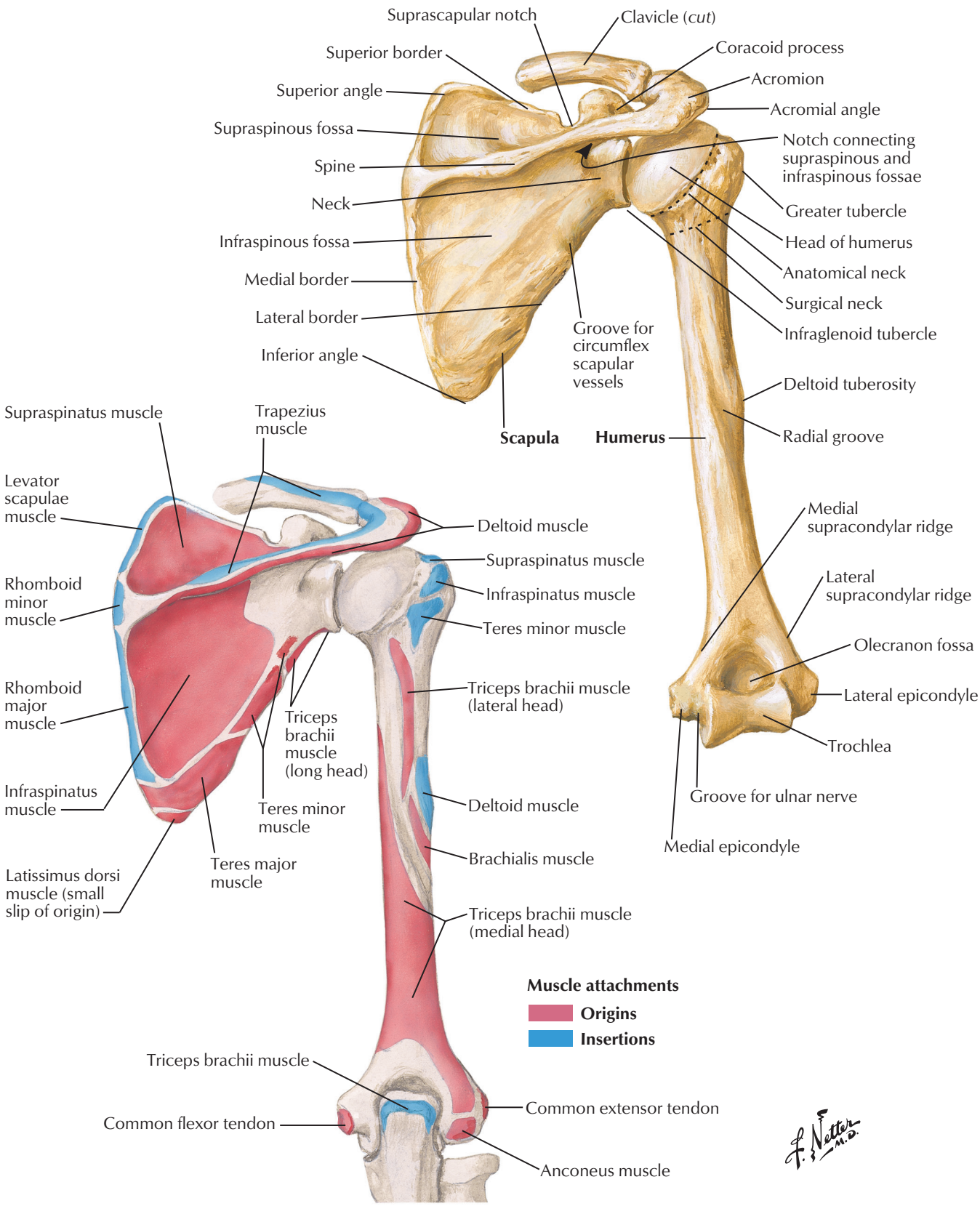
Humerus and Scapula: Anterior Views

See also **Plates 183, 407, 422**



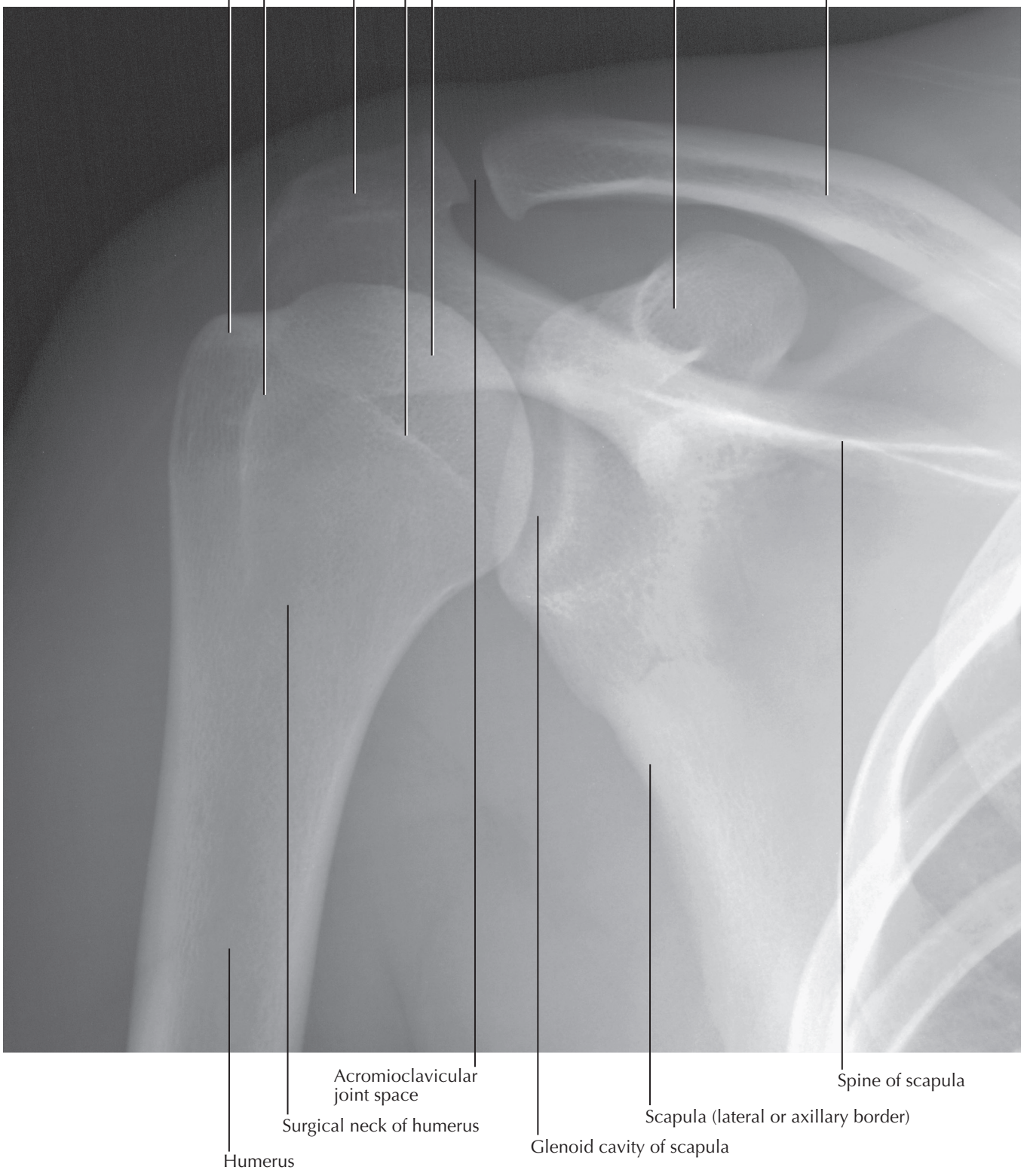
Humerus and Scapula: Posterior View

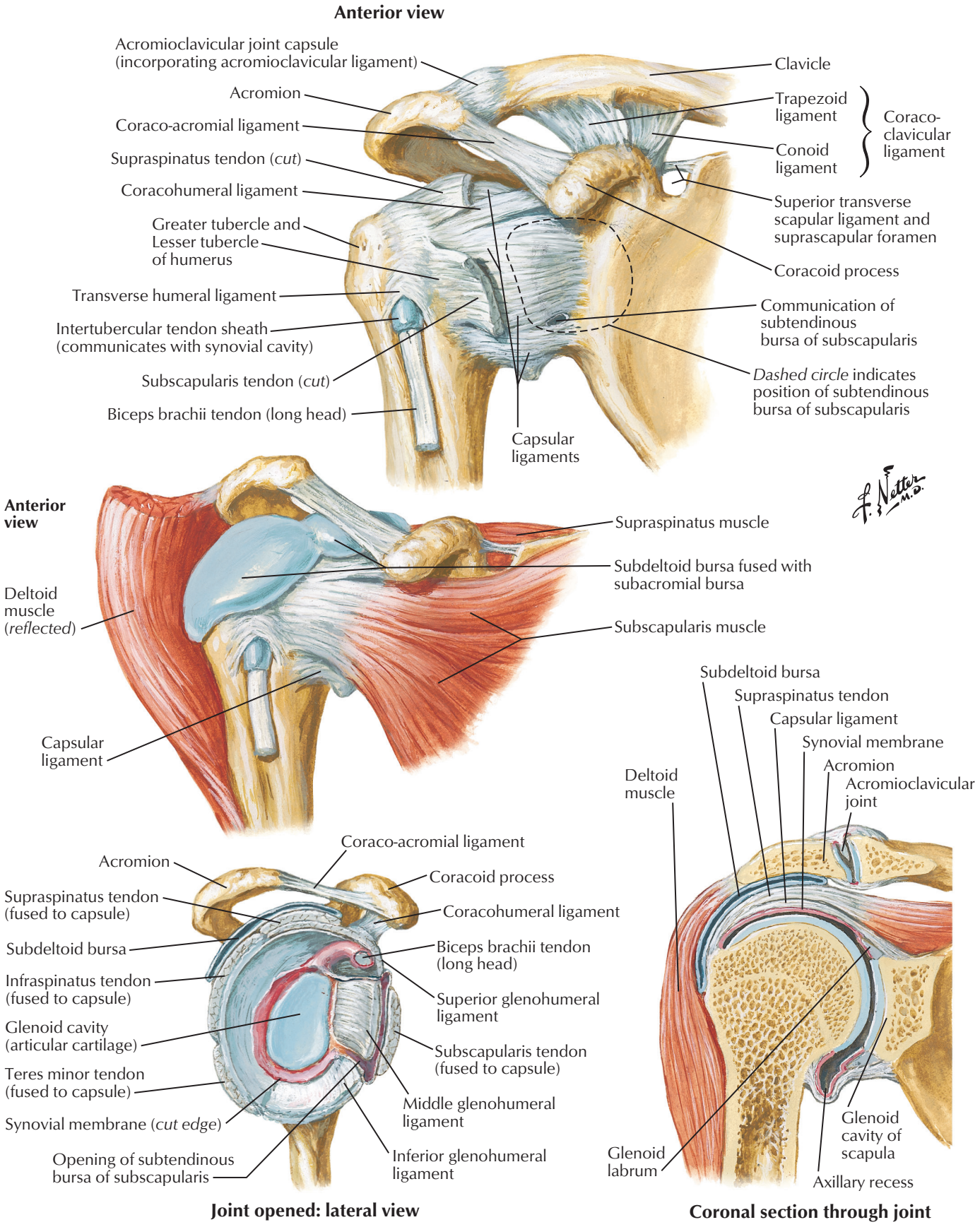
See also **Plate 183**



Shoulder: Anteroposterior Radiograph

See also **Plate 405**



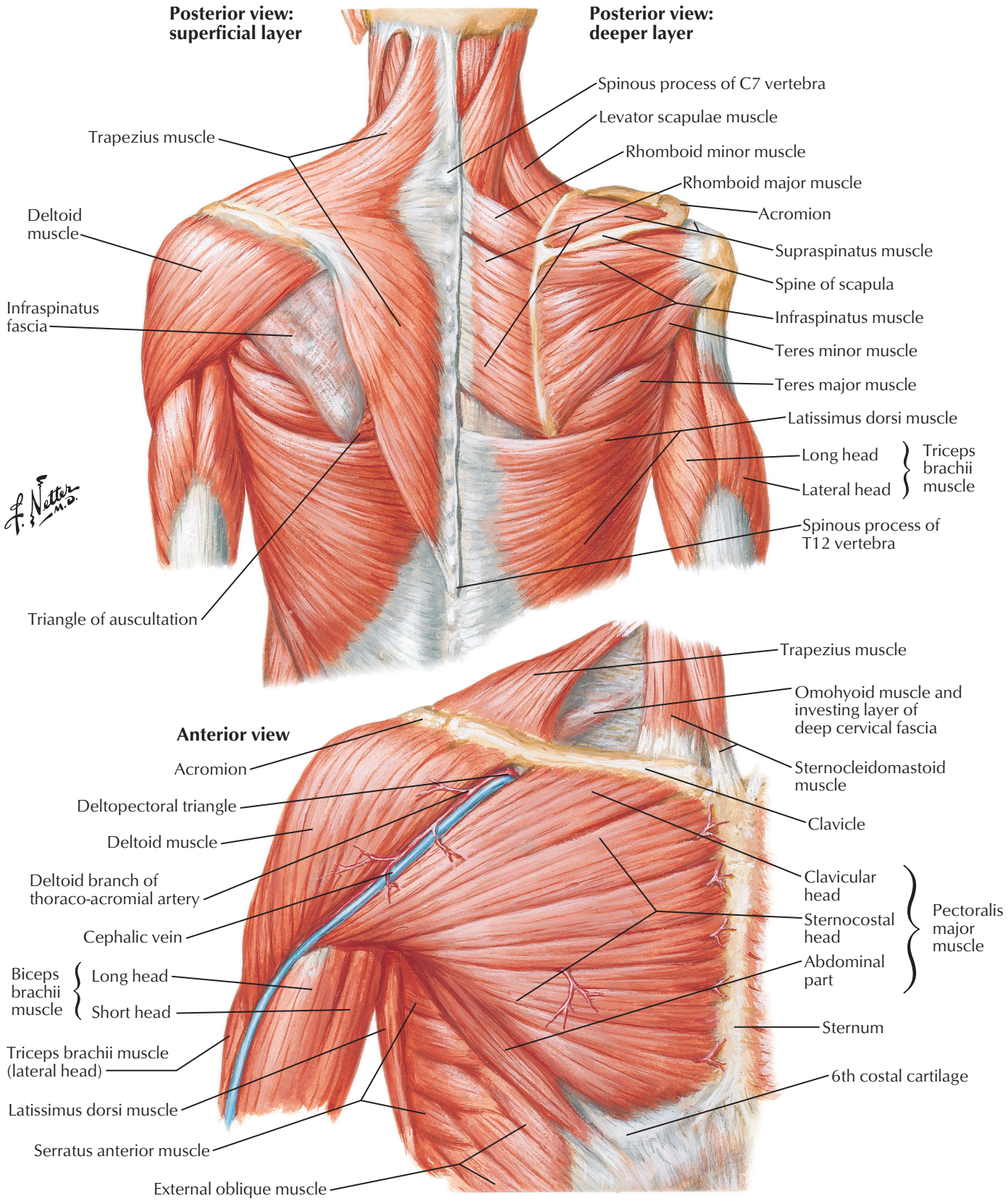


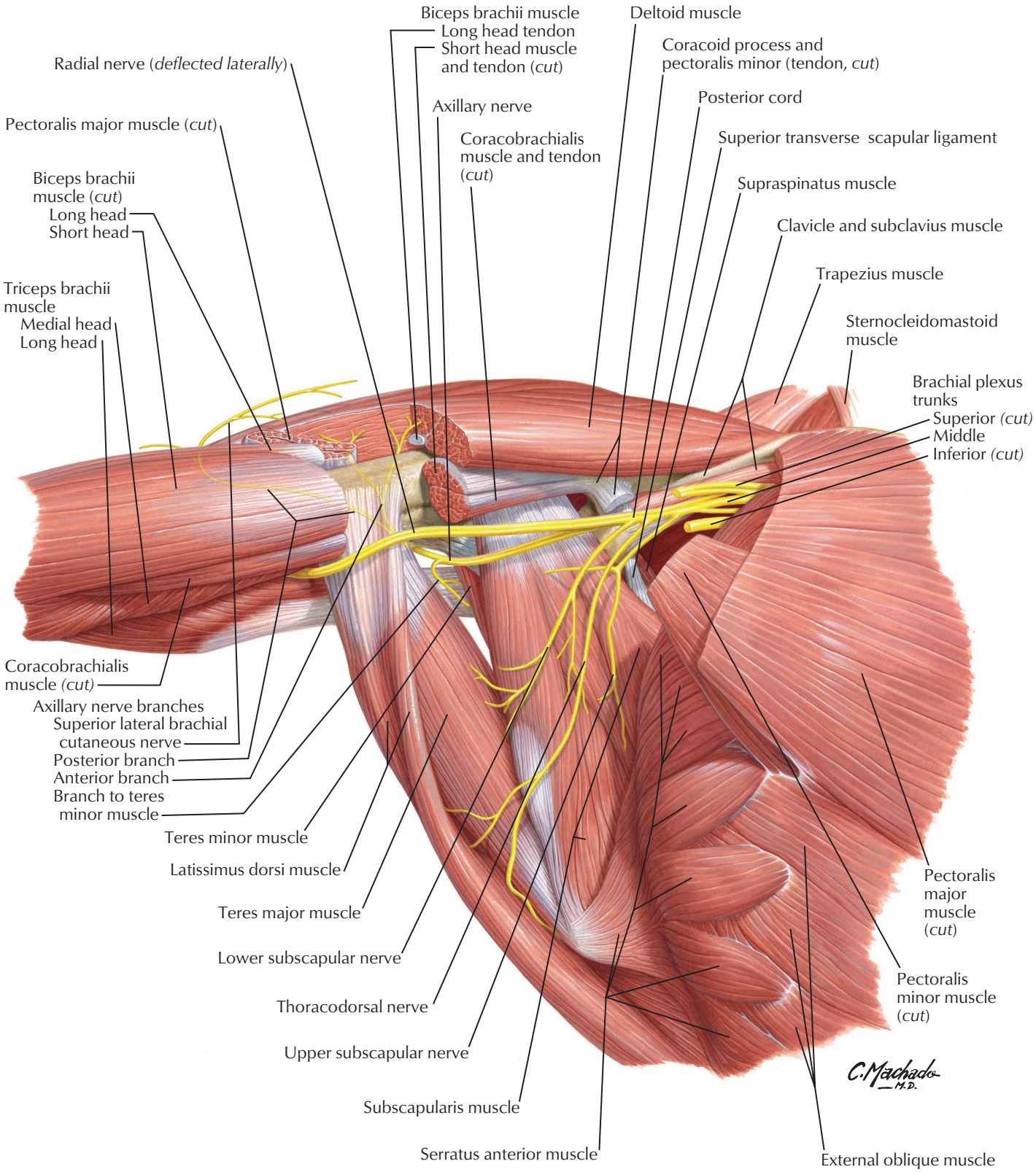
Joint opened: lateral view

Coronal section through joint

Muscles of Shoulder

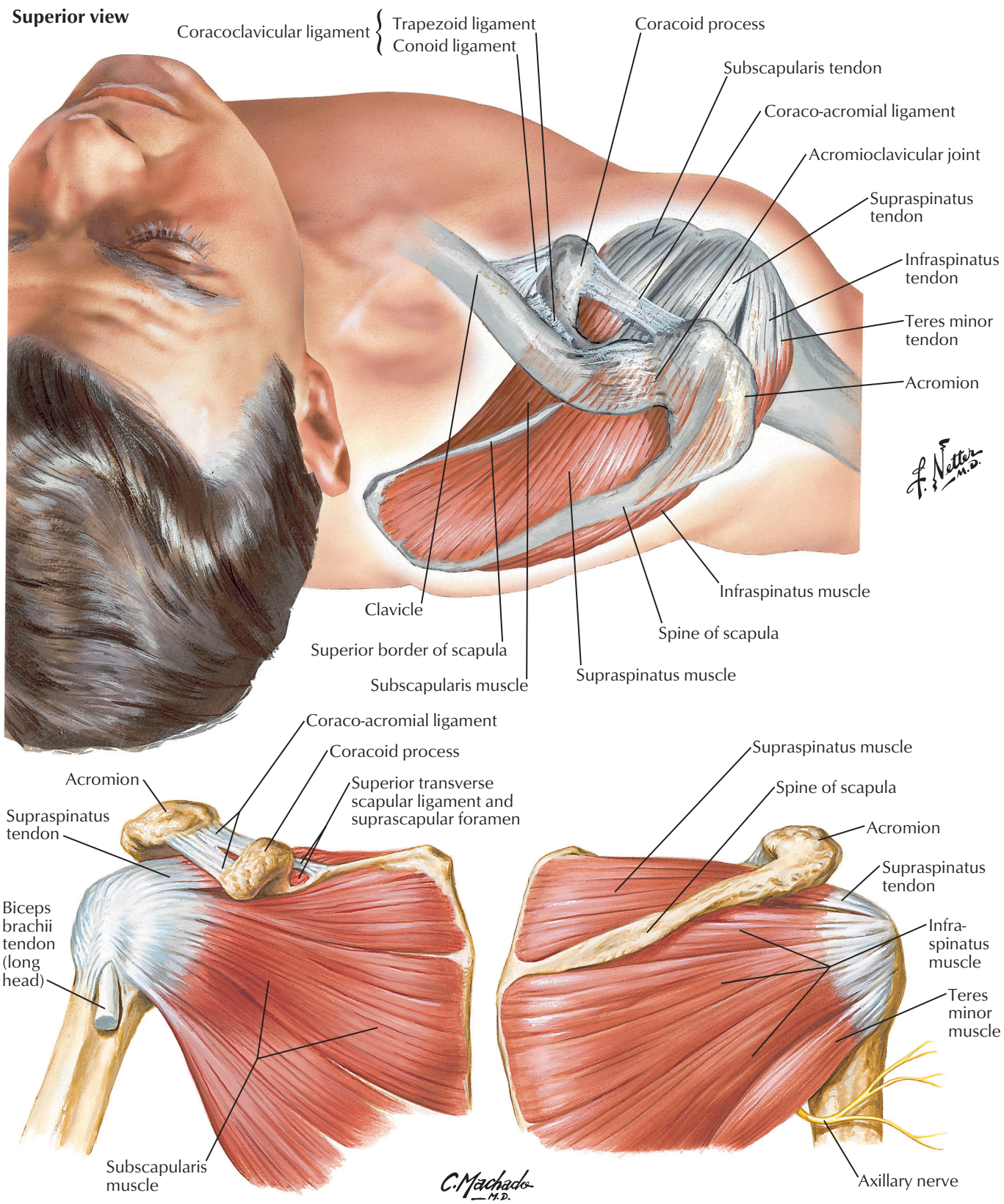
See also **Plates 29, 171, 185**

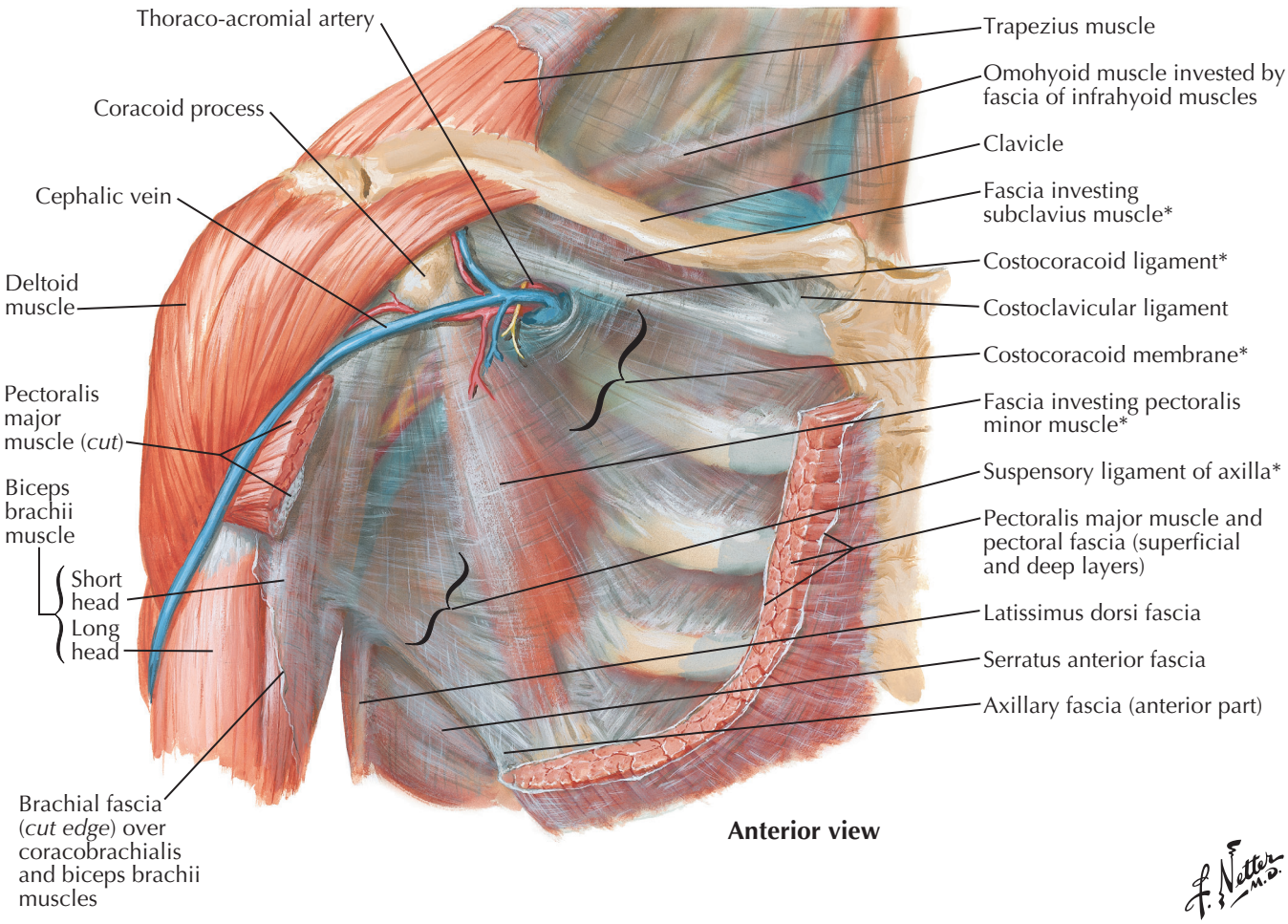



Biceps brachii muscle
Long head tendon
Short head muscle and tendon (cut)
Deltoid muscle
Radial nerve (deflected laterally)
Coracoid process and pectoralis minor (tendon, cut)
Axillary nerve
Posterior cord
Pectoralis major muscle (cut)
Coracobrachialis muscle and tendon (cut)
Superior transverse scapular ligament
Biceps brachii muscle (cut)
Long head
Short head
Supraspinatus muscle
Clavicle and subclavius muscle
Trapezius muscle
Triceps brachii muscle
Medial head
Long head
Sternocleidomastoid muscle
Brachial plexus trunks
Superior (cut)
Middle
Inferior (cut)
Coracobrachialis muscle (cut)
Axillary nerve branches
Superior lateral brachial cutaneous nerve
Posterior branch
Anterior branch
Branch to teres minor muscle
Teres minor muscle
Latissimus dorsi muscle
Teres major muscle
Lower subscapular nerve
Thoracodorsal nerve
Upper subscapular nerve
Subscapularis muscle
Serratus anterior muscle
Pectoralis major muscle (cut)
Pectoralis minor muscle (cut)
External oblique muscle
C. Machado M.D.

Muscles of Rotator Cuff

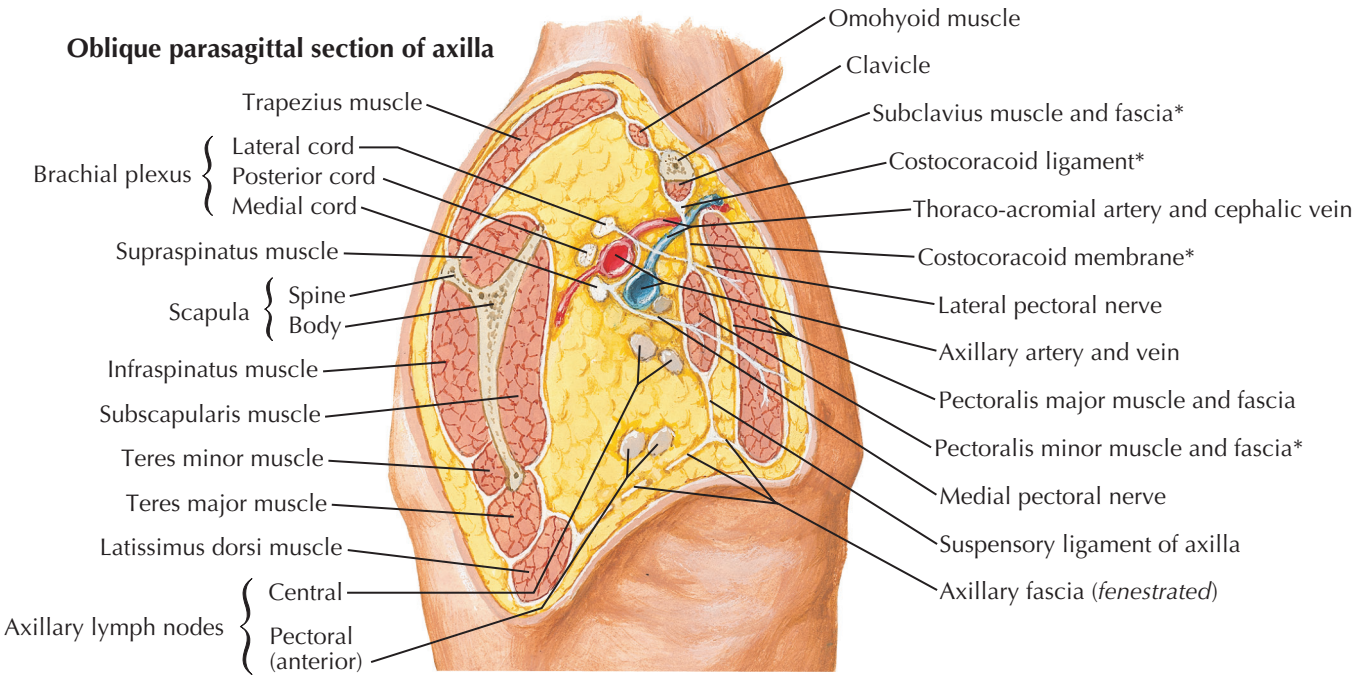
See also Plates 408, 417, 418





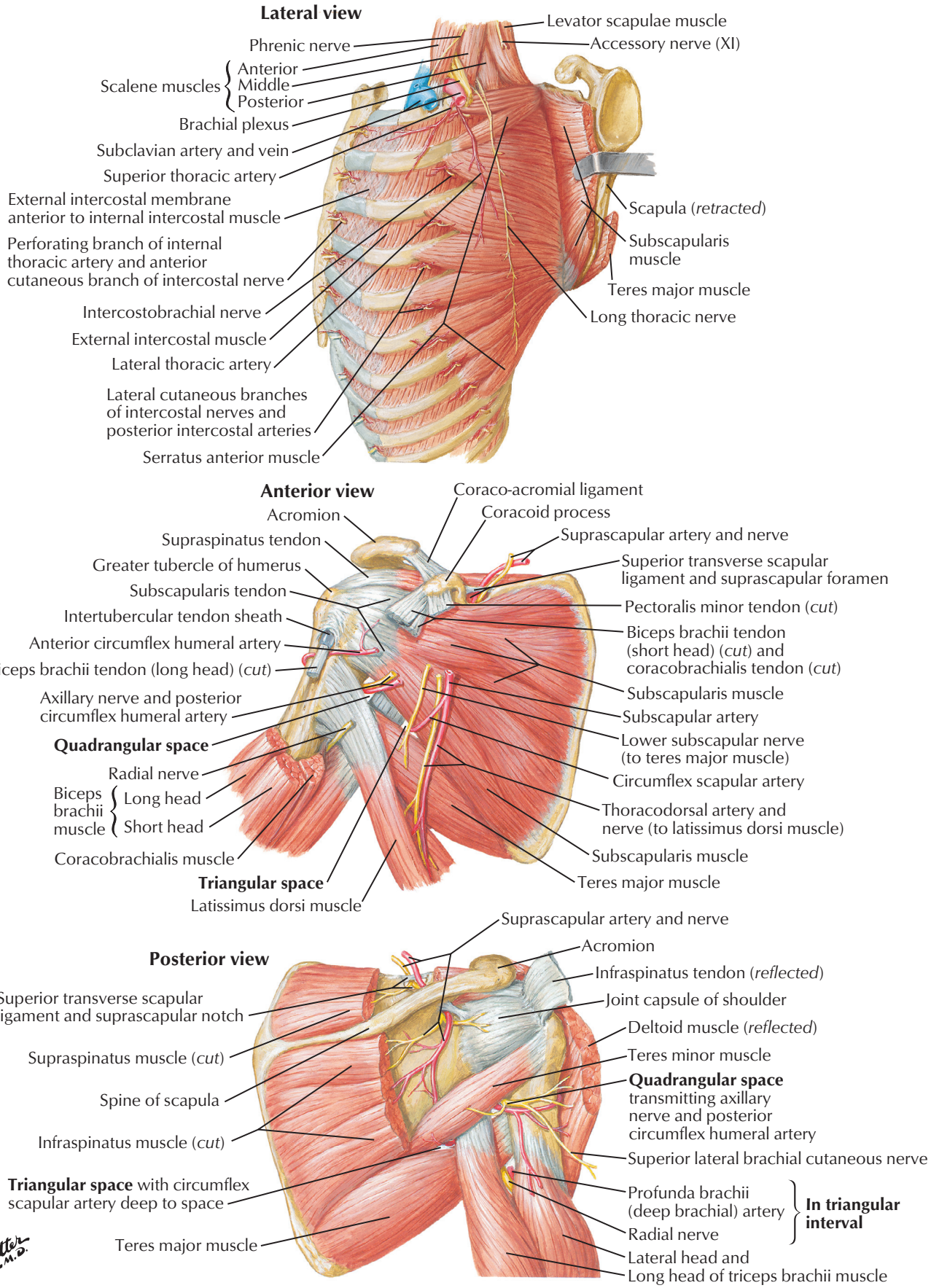
Anterior view

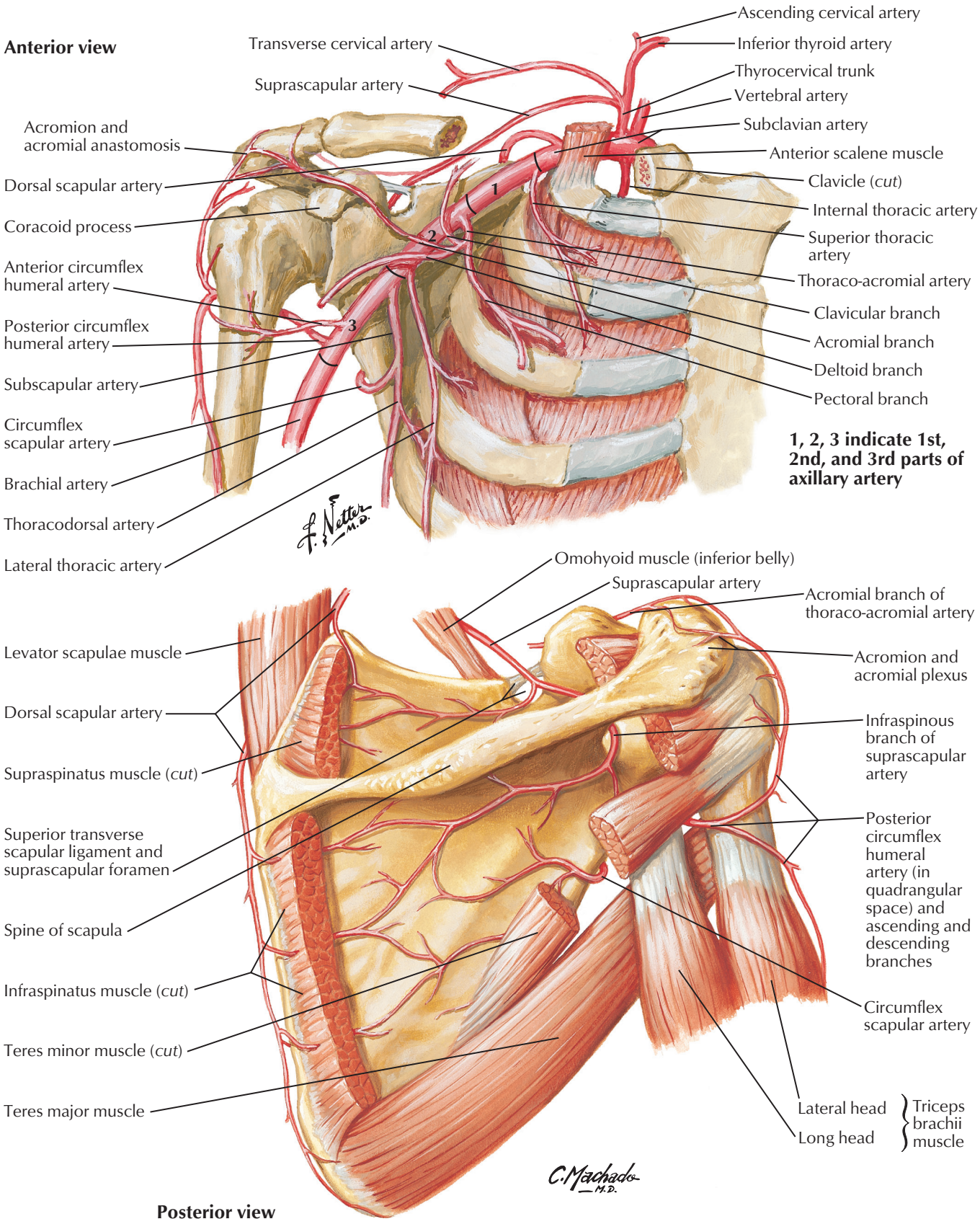
Oblique parasagittal section of axilla



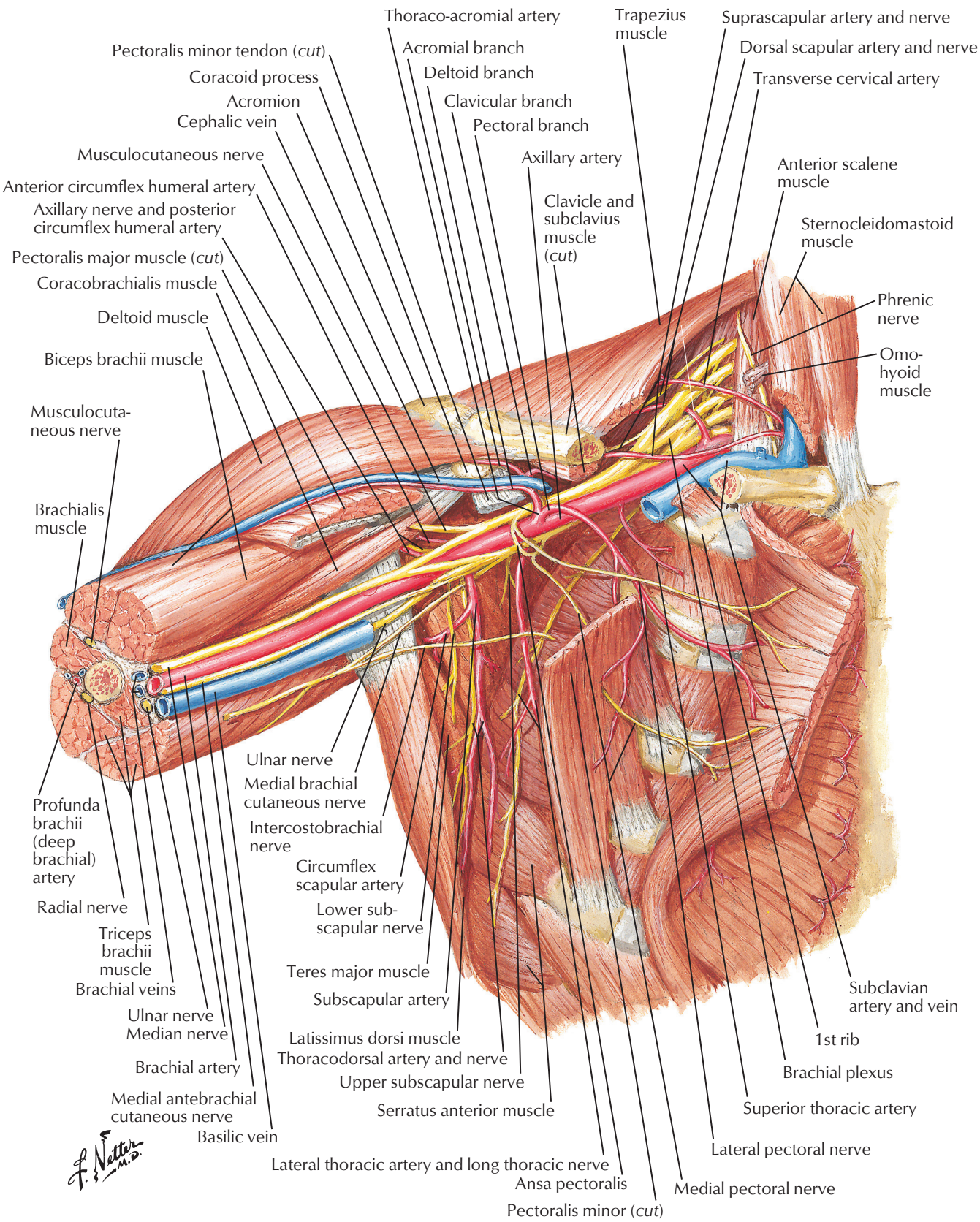
*Components of clavipectoral fascia

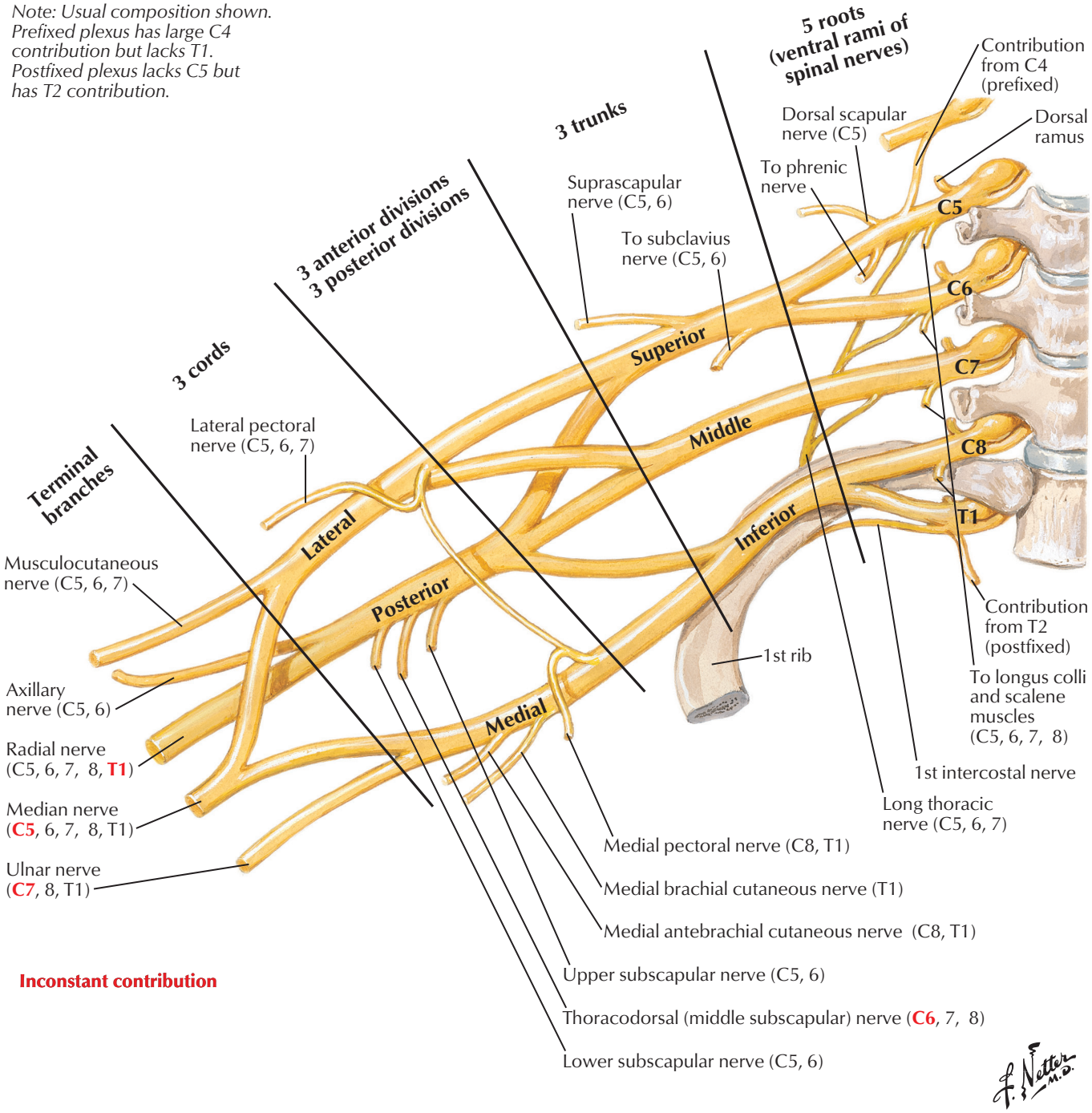
See also Plates 415, 465




Anterior view
Ascending cervical artery
Transverse cervical artery
Inferior thyroid artery
Suprascapular artery
Thyrocervical trunk
Vertebral artery
Acromion and acromial anastomosis
Subclavian artery
Anterior scalene muscle
Dorsal scapular artery
Clavicle (cut)
Coracoid process
Internal thoracic artery
Superior thoracic artery
Anterior circumflex humeral artery
Thoraco-acromial artery
Clavicular branch
Posterior circumflex humeral artery
Acromial branch
Deltoid branch
Subscapular artery
Pectoral branch
Circumflex scapular artery
1, 2, 3 indicate 1st, 2nd, and 3rd parts of axillary artery
Brachial artery
Thoracodorsal artery
Lateral thoracic artery
Omohyoid muscle (inferior belly)
Suprascapular artery
Acromial branch of thoraco-acromial artery
Levator scapulae muscle
Acromion and acromial plexus
Dorsal scapular artery
Infraspinous branch of suprascapular artery
Supraspinatus muscle (cut)
Posterior circumflex humeral artery (in quadrangular space) and ascending and descending branches
Superior transverse scapular ligament and suprascapular foramen
Spine of scapula
Circumflex scapular artery
Infraspinatus muscle (cut)
Lateral head
Long head
Triceps brachii muscle
Teres minor muscle (cut)
Teres major muscle
Posterior view

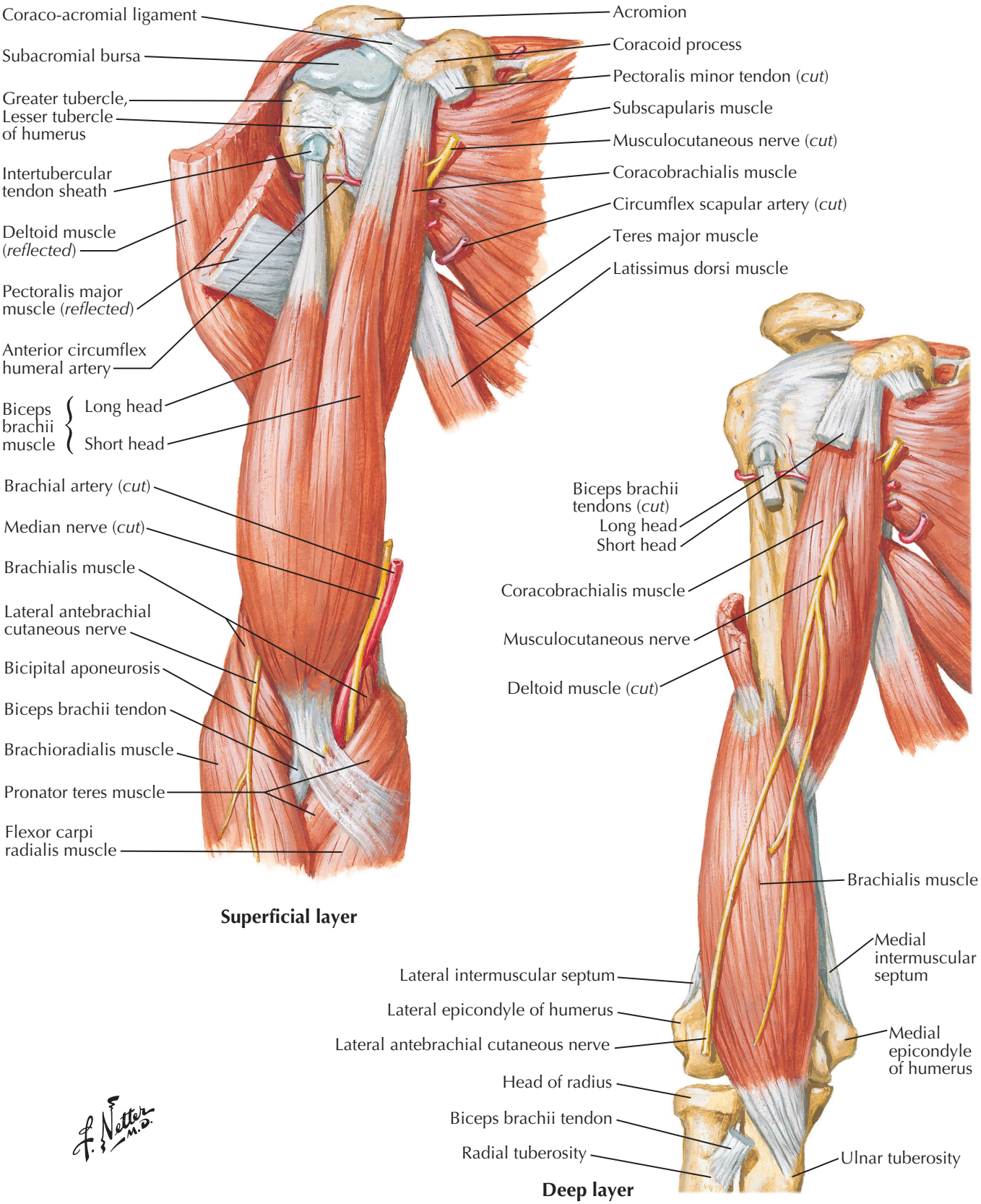
See also Plates 410, 413




Note: Usual composition shown. Prefixed plexus has large C4 contribution but lacks T1. Postfixed plexus lacks C5 but has T2 contribution.
5 roots (ventral rami of spinal nerves)
3 trunks
3 anterior divisions
3 posterior divisions
3 cords
Terminal branches
Contribution from C4 (prefixed)
Dorsal scapular nerve (C5)
Dorsal ramus
To phrenic nerve
Suprascapular nerve (C5, 6)
To subclavius nerve (C5, 6)
C5
C6
C7
C8
T1
Superior
Middle
Inferior
Lateral
Posterior
Medial
Lateral pectoral nerve (C5, 6, 7)
Musculocutaneous nerve (C5, 6, 7)
Axillary nerve (C5, 6)
Radial nerve (C5, 6, 7, 8, T1)
Median nerve (C5, 6, 7, 8, T1)
Ulnar nerve (C7, 8, T1)
1st rib
Contribution from T2 (postfixed)
To longus colli and scalene muscles (C5, 6, 7, 8)
1st intercostal nerve
Long thoracic nerve (C5, 6, 7)
Medial pectoral nerve (C8, T1)
Medial brachial cutaneous nerve (T1)
Medial antebrachial cutaneous nerve (C8, T1)
Upper subscapular nerve (C5, 6)
Thoracodorsal (middle subscapular) nerve (C6, 7, 8)
Lower subscapular nerve (C5, 6)
Inconstant contribution

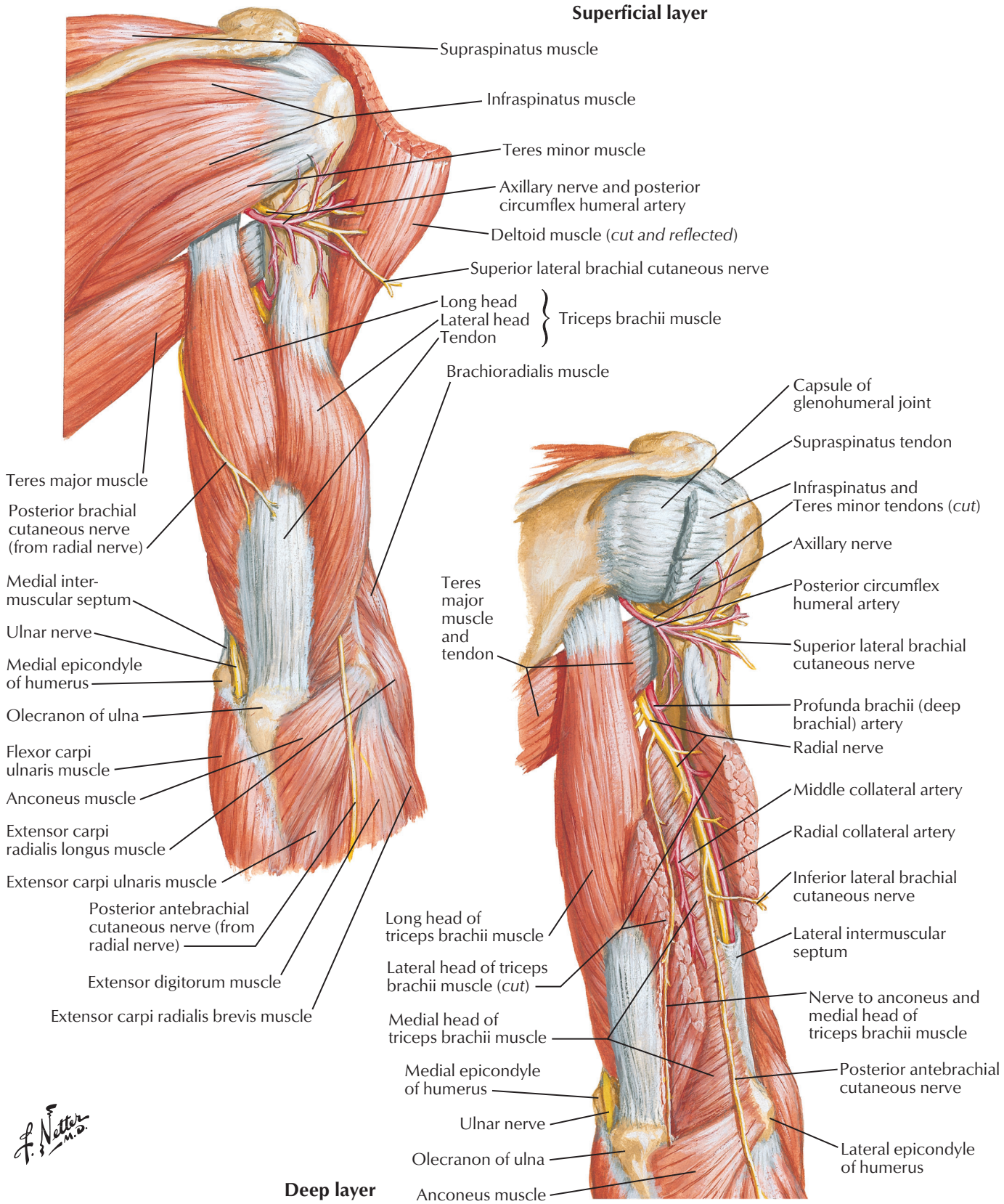
Muscles of Arm: Anterior Views

See also Plates 411, 462



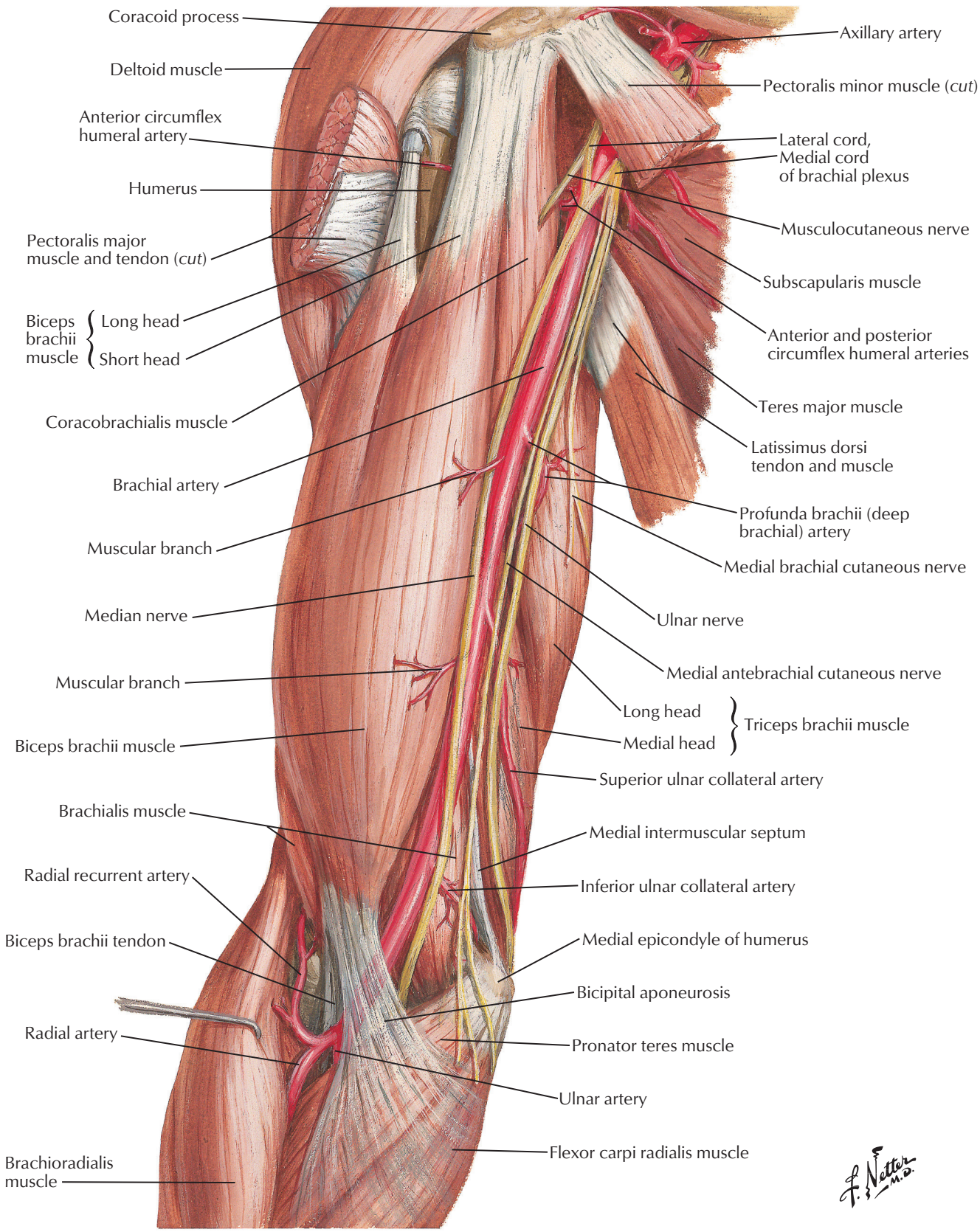
Superficial layer

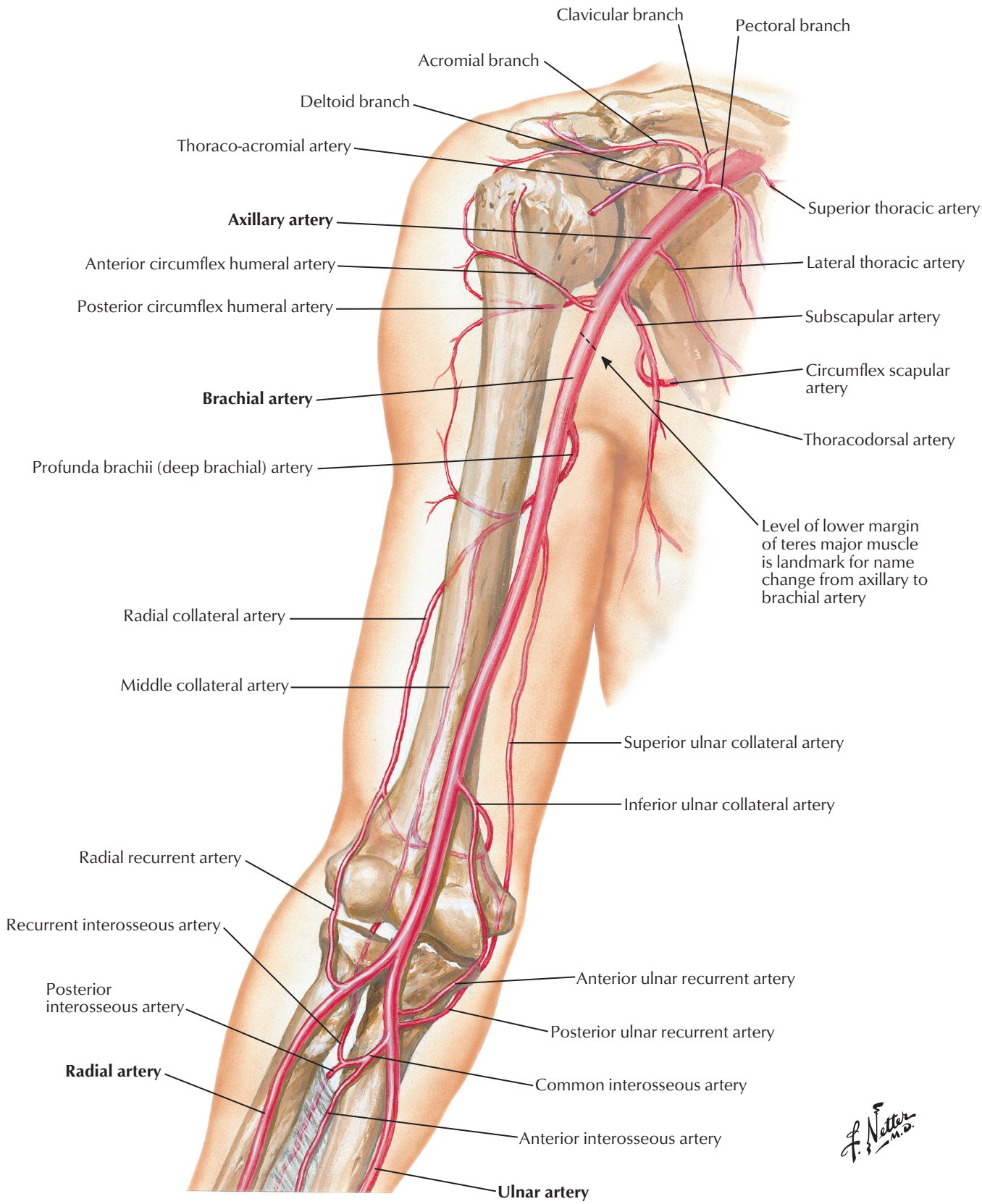
Deep layer

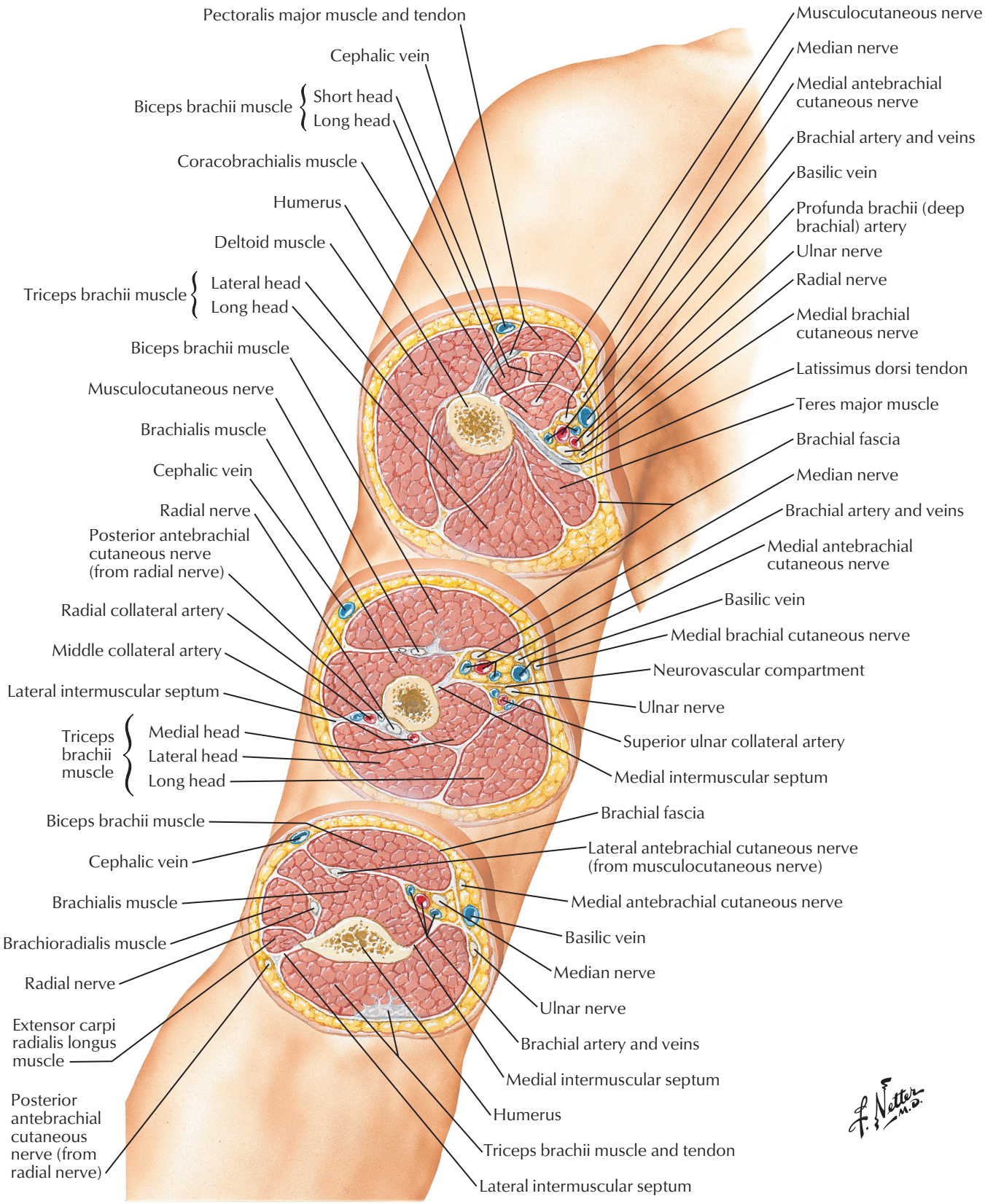

Superficial layer
Supraspinatus muscle
Infraspinatus muscle
Teres minor muscle
Axillary nerve and posterior circumflex humeral artery
Deltoid muscle (cut and reflected)
Superior lateral brachial cutaneous nerve
Long head
Lateral head
Tendon
Triceps brachii muscle
Brachioradialis muscle
Teres major muscle
Posterior brachial cutaneous nerve (from radial nerve)
Medial intermuscular septum
Ulnar nerve
Medial epicondyle of humerus
Olecranon of ulna
Flexor carpi ulnaris muscle
Anconeus muscle
Extensor carpi radialis longus muscle
Extensor carpi ulnaris muscle
Posterior antebrachial cutaneous nerve (from radial nerve)
Extensor digitorum muscle
Extensor carpi radialis brevis muscle
Capsule of glenohumeral joint
Supraspinatus tendon
Infraspinatus and Teres minor tendons (cut)
Axillary nerve
Posterior circumflex humeral artery
Teres major muscle and tendon
Superior lateral brachial cutaneous nerve
Profunda brachii (deep brachial) artery
Radial nerve
Middle collateral artery
Radial collateral artery
Inferior lateral brachial cutaneous nerve
Lateral intermuscular septum
Long head of triceps brachii muscle
Lateral head of triceps brachii muscle (cut)
Nerve to anconeus and medial head of triceps brachii muscle
Medial head of triceps brachii muscle
Posterior antebrachial cutaneous nerve
Medial epicondyle of humerus
Ulnar nerve
Olecranon of ulna
Lateral epicondyle of humerus
Anconeus muscle
Deep layer

Brachial Artery in Situ

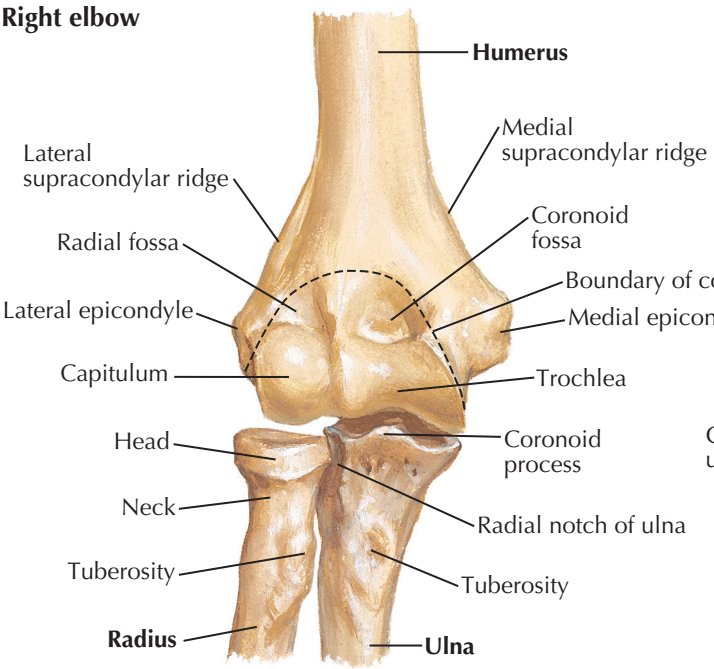
See also Plate 401



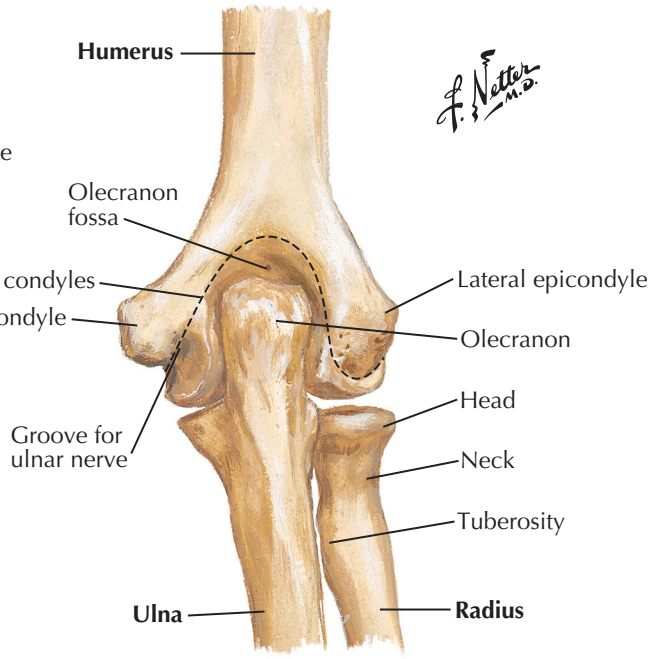

Clavicular branch
Pectoral branch
Acromial branch
Deltoid branch
Thoraco-acromial artery
Superior thoracic artery
Axillary artery
Anterior circumflex humeral artery
Lateral thoracic artery
Posterior circumflex humeral artery
Subscapular artery
Circumflex scapular artery
Brachial artery
Thoracodorsal artery
Profunda brachii (deep brachial) artery
Level of lower margin of teres major muscle is landmark for name change from axillary to brachial artery
Radial collateral artery
Middle collateral artery
Superior ulnar collateral artery
Inferior ulnar collateral artery
Radial recurrent artery
Recurrent interosseous artery
Anterior ulnar recurrent artery
Posterior interosseous artery
Posterior ulnar recurrent artery
Radial artery
Common interosseous artery
Anterior interosseous artery
Ulnar artery


Pectoralis major muscle and tendon
Cephalic vein
Biceps brachii muscle
Short head
Long head
Coracobrachialis muscle
Humerus
Deltoid muscle
Triceps brachii muscle
Lateral head
Long head
Biceps brachii muscle
Musculocutaneous nerve
Brachialis muscle
Cephalic vein
Radial nerve
Posterior antebrachial cutaneous nerve (from radial nerve)
Radial collateral artery
Middle collateral artery
Lateral intermuscular septum
Triceps brachii muscle
Medial head
Lateral head
Long head
Biceps brachii muscle
Cephalic vein
Brachialis muscle
Brachioradialis muscle
Radial nerve
Extensor carpi radialis longus muscle
Posterior antebrachial cutaneous nerve (from radial nerve)
Musculocutaneous nerve
Median nerve
Medial antebrachial cutaneous nerve
Brachial artery and veins
Basilic vein
Profunda brachii (deep brachial) artery
Ulnar nerve
Radial nerve
Medial brachial cutaneous nerve
Latissimus dorsi tendon
Teres major muscle
Brachial fascia
Median nerve
Brachial artery and veins
Medial antebrachial cutaneous nerve
Basilic vein
Medial brachial cutaneous nerve
Neurovascular compartment
Ulnar nerve
Superior ulnar collateral artery
Medial intermuscular septum
Brachial fascia
Lateral antebrachial cutaneous nerve (from musculocutaneous nerve)
Medial antebrachial cutaneous nerve
Basilic vein
Median nerve
Ulnar nerve
Brachial artery and veins
Medial intermuscular septum
Humerus
Triceps brachii muscle and tendon
Lateral intermuscular septum

Right elbow

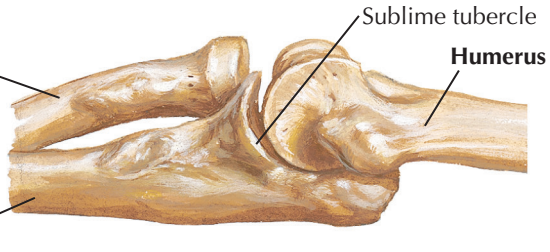


In extension: anterior view

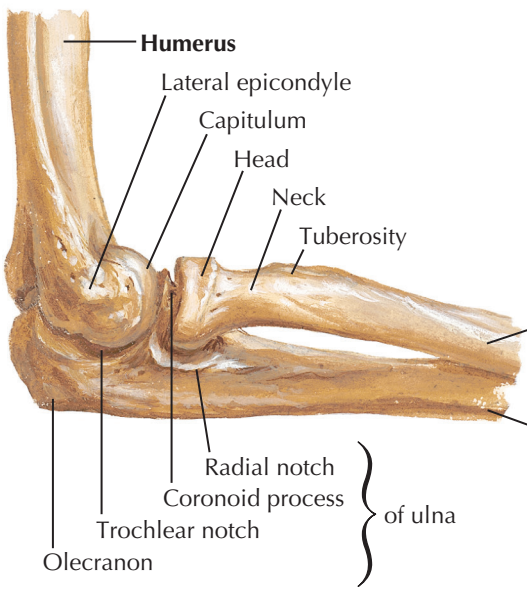


In extension: posterior view

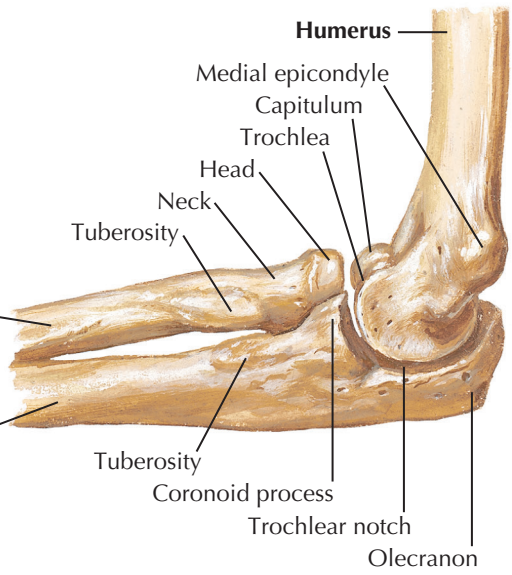
In extension: lateral view



In extension: medial view

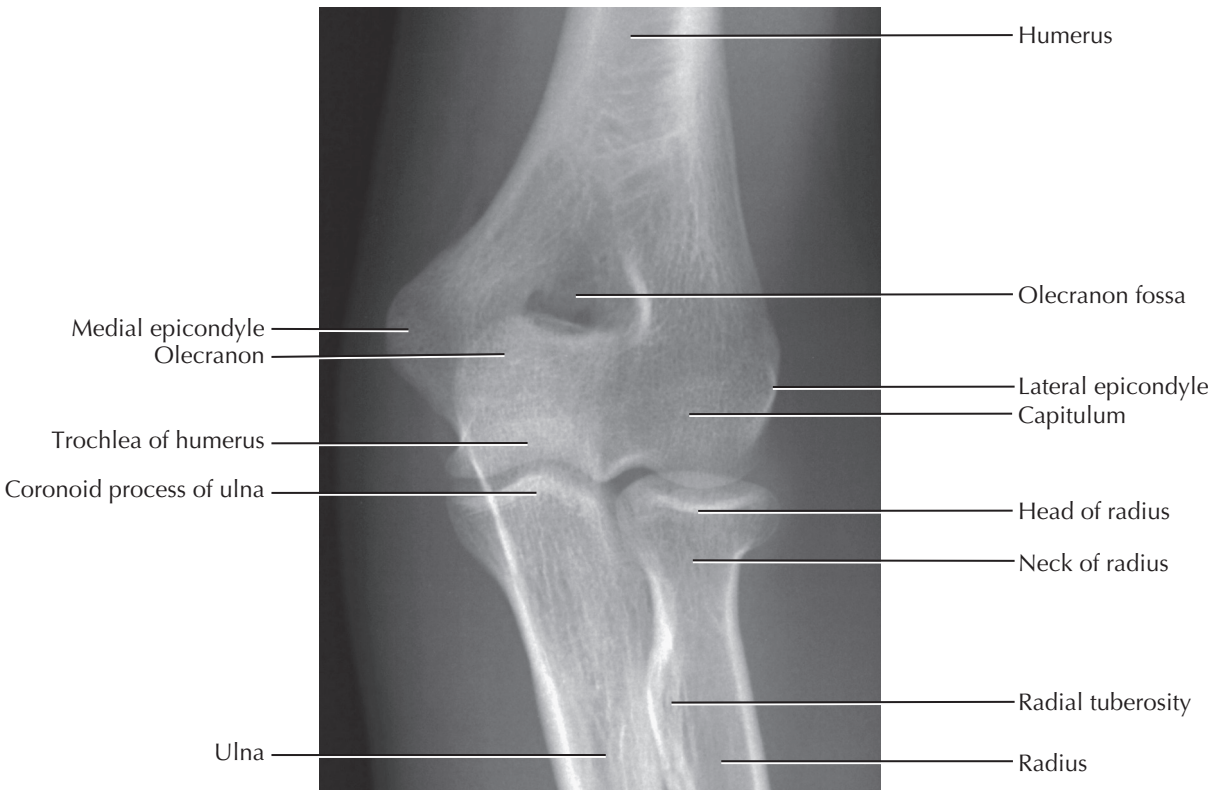


In 90° flexion: lateral view

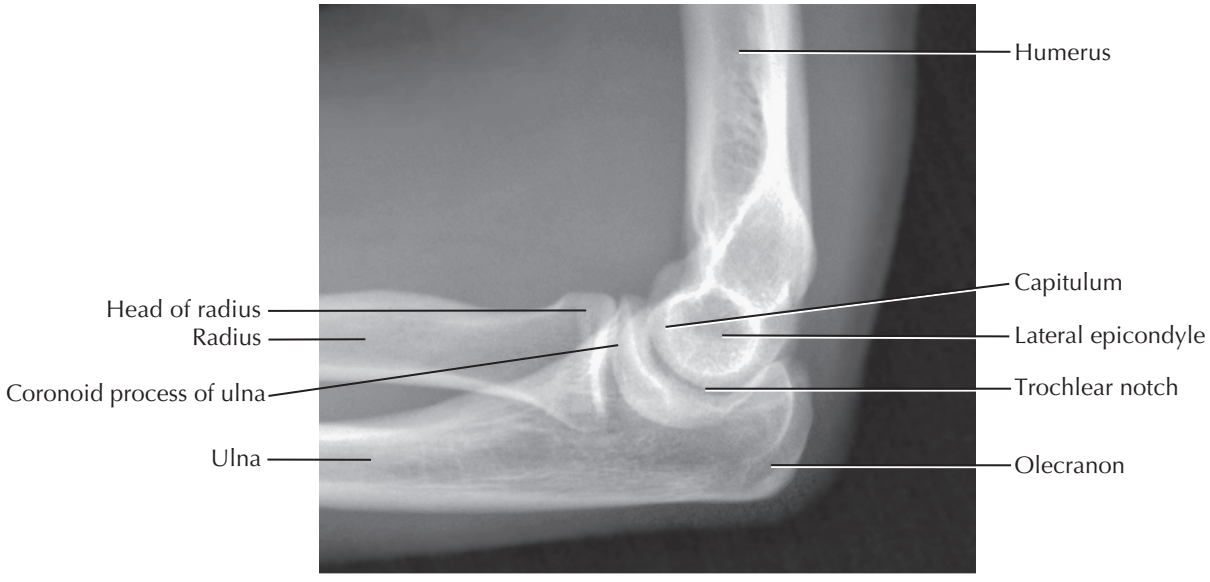


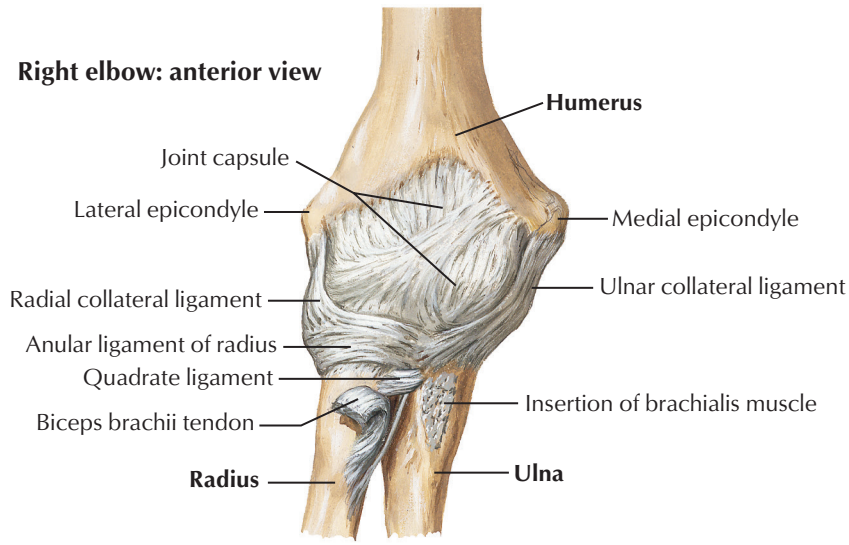
In 90° flexion: medial view

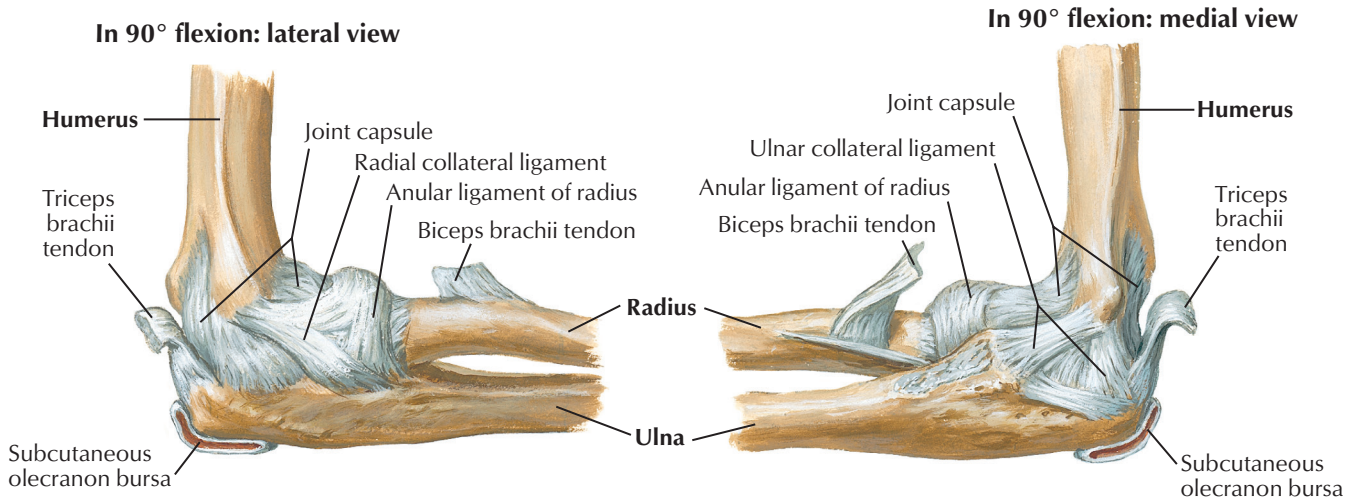
Anteroposterior radiograph

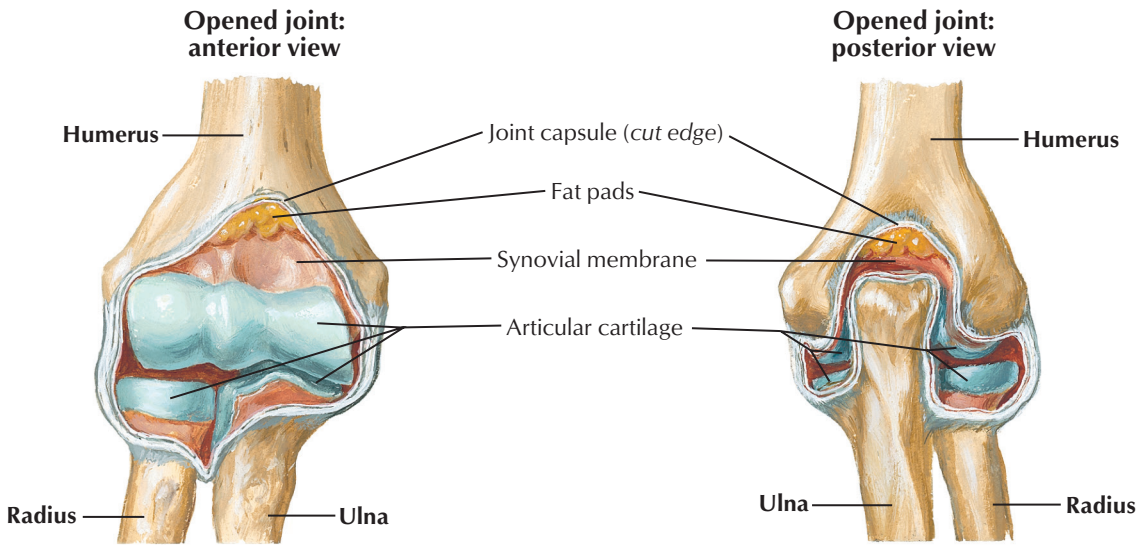


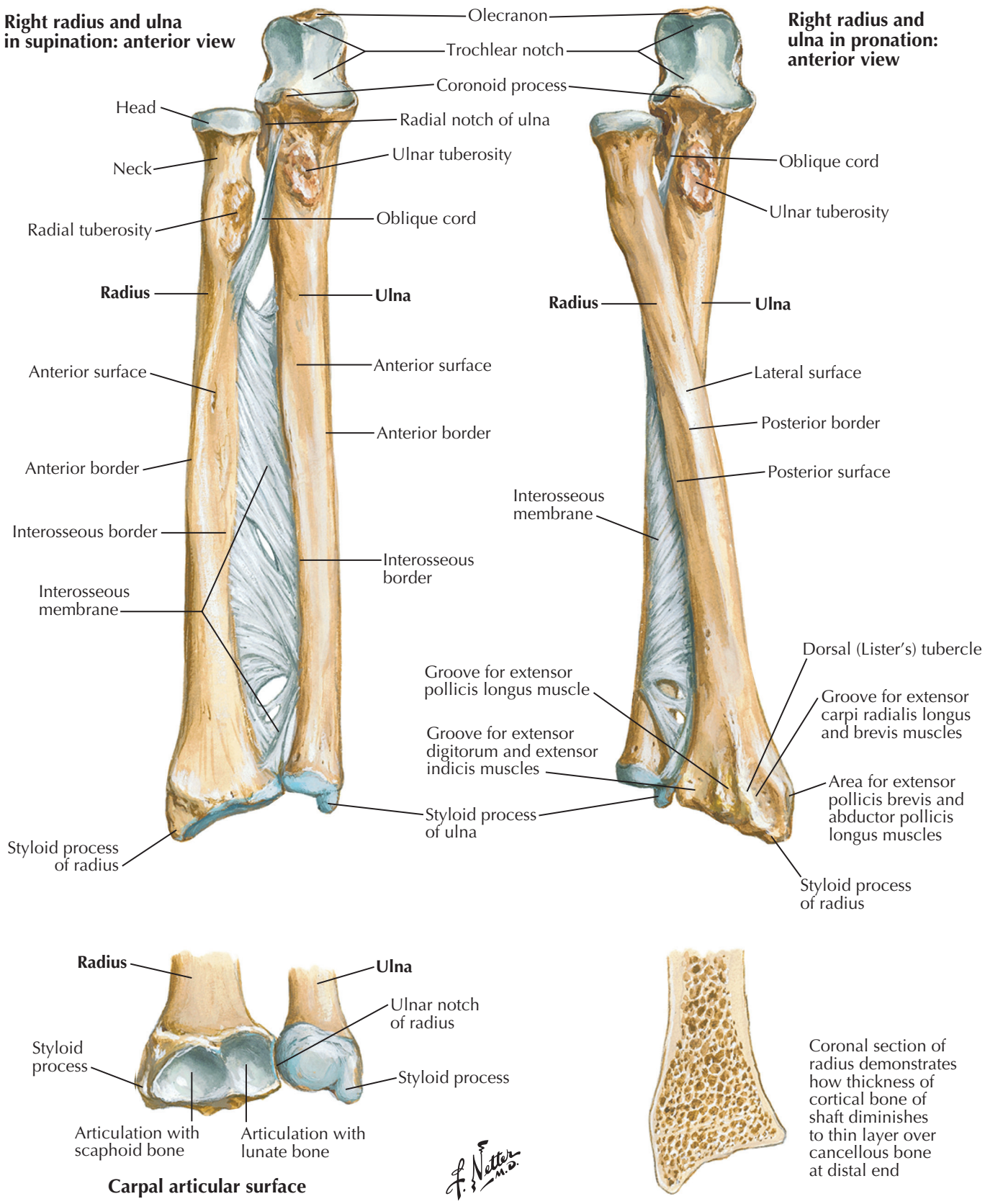
Lateral radiograph



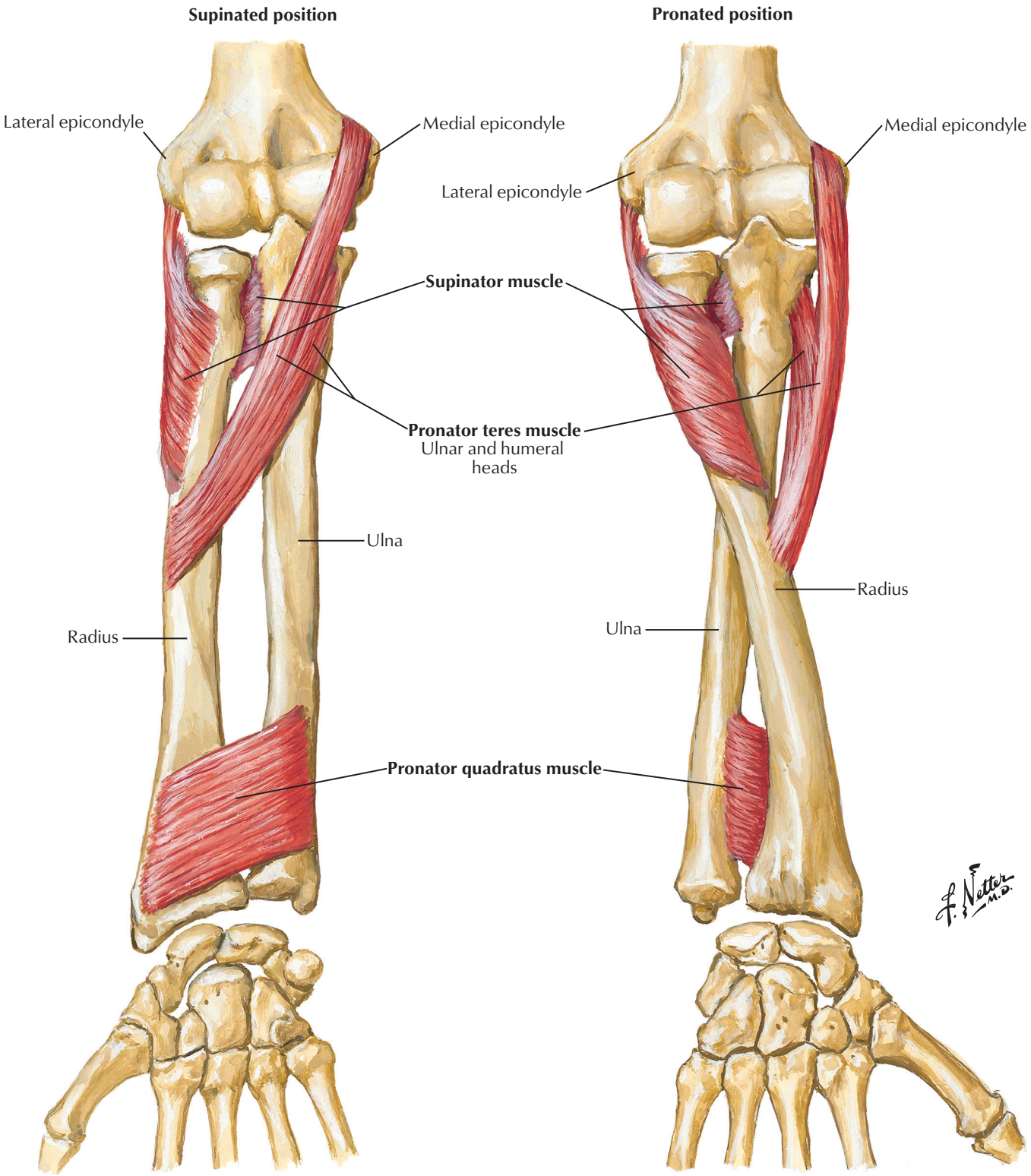

Right elbow: anterior view
Humerus
Joint capsule
Lateral epicondyle
Medial epicondyle
Radial collateral ligament
Ulnar collateral ligament
Anular ligament of radius
Quadrate ligament
Insertion of brachialis muscle
Biceps brachii tendon
Radius
Ulna


In 90° flexion: lateral view
Humerus
Joint capsule
Radial collateral ligament
Anular ligament of radius
Biceps brachii tendon
Triceps brachii tendon
Radius
Ulna
Subcutaneous olecranon bursa
In 90° flexion: medial view
Joint capsule
Humerus
Ulnar collateral ligament
Anular ligament of radius
Biceps brachii tendon
Triceps brachii tendon
Subcutaneous olecranon bursa


Opened joint: anterior view
Humerus
Joint capsule (cut edge)
Fat pads
Synovial membrane
Articular cartilage
Radius
Ulna
Opened joint: posterior view
Humerus
Ulna
Radius

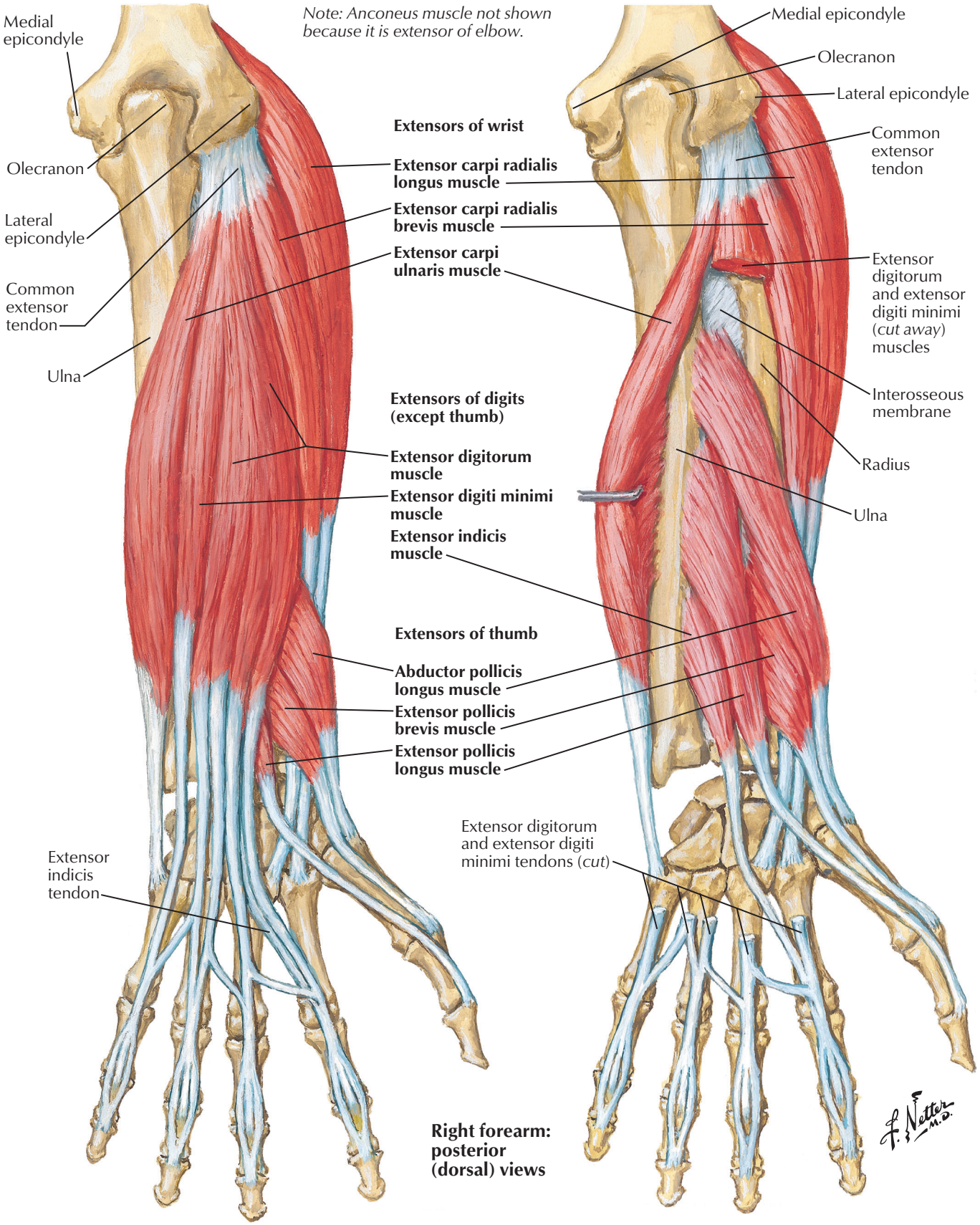

Right radius and ulna in supination: anterior view
Olecranon
Trochlear notch
Coronoid process
Head
Radial notch of ulna
Neck
Ulnar tuberosity
Radial tuberosity
Oblique cord
Radius
Ulna
Anterior surface
Anterior surface
Anterior border
Anterior border
Interosseous border
Interosseous border
Interosseous membrane
Styloid process of radius
Styloid process of ulna
Right radius and ulna in pronation: anterior view
Oblique cord
Ulnar tuberosity
Radius
Ulna
Lateral surface
Posterior border
Posterior surface
Interosseous membrane
Dorsal (Lister's) tubercle
Groove for extensor pollicis longus muscle
Groove for extensor carpi radialis longus and brevis muscles
Groove for extensor digitorum and extensor indicis muscles
Area for extensor pollicis brevis and abductor pollicis longus muscles
Styloid process of radius
Radius
Ulna
Ulnar notch of radius
Styloid process
Styloid process
Articulation with scaphoid bone
Articulation with lunate bone
Carpal articular surface
Coronal section of radius demonstrates how thickness of cortical bone of shaft diminishes to thin layer over cancellous bone at distal end

Right forearm: anterior view

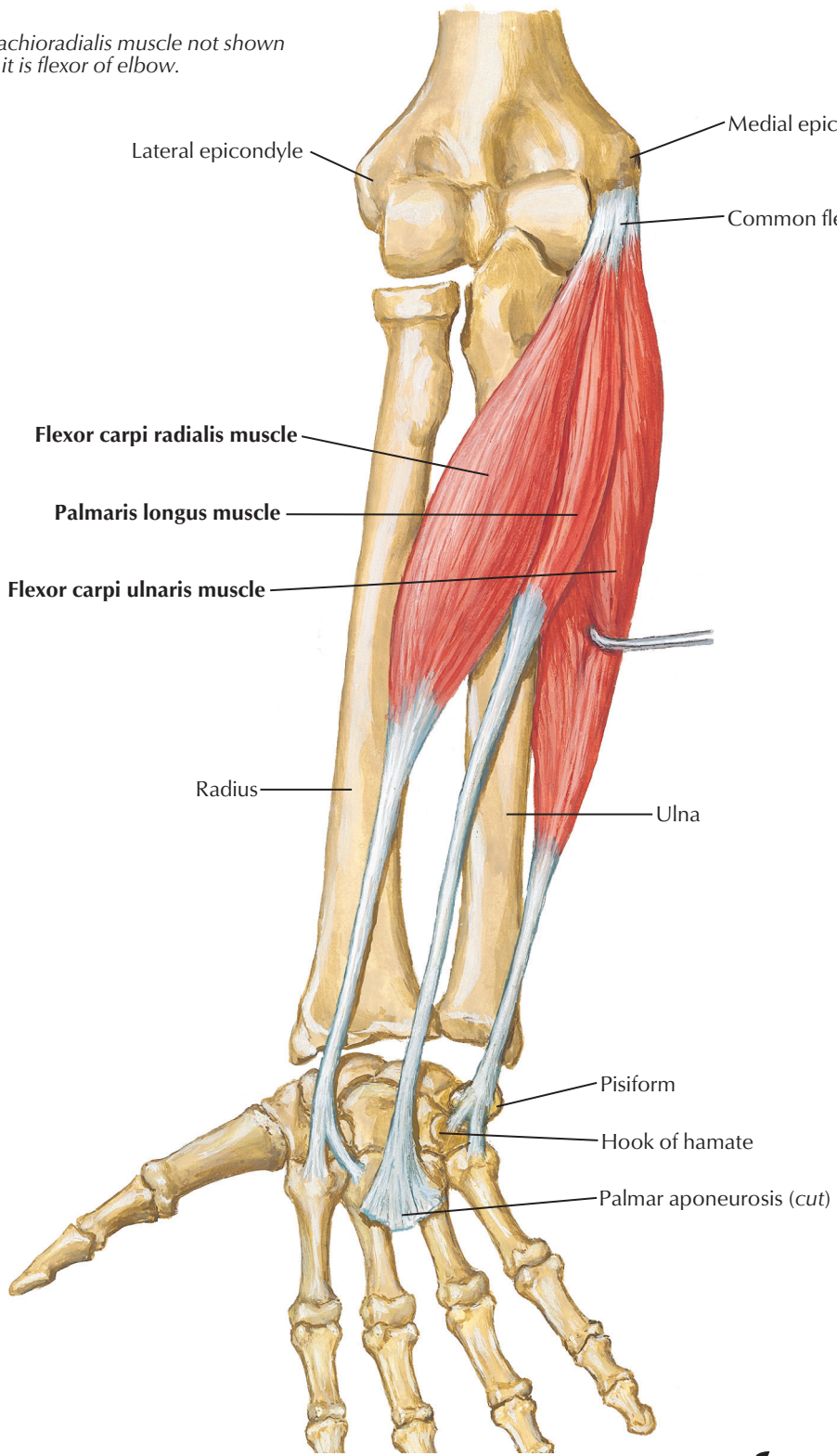


Individual Muscles of Forearm: Extensors of Wrist and Digits

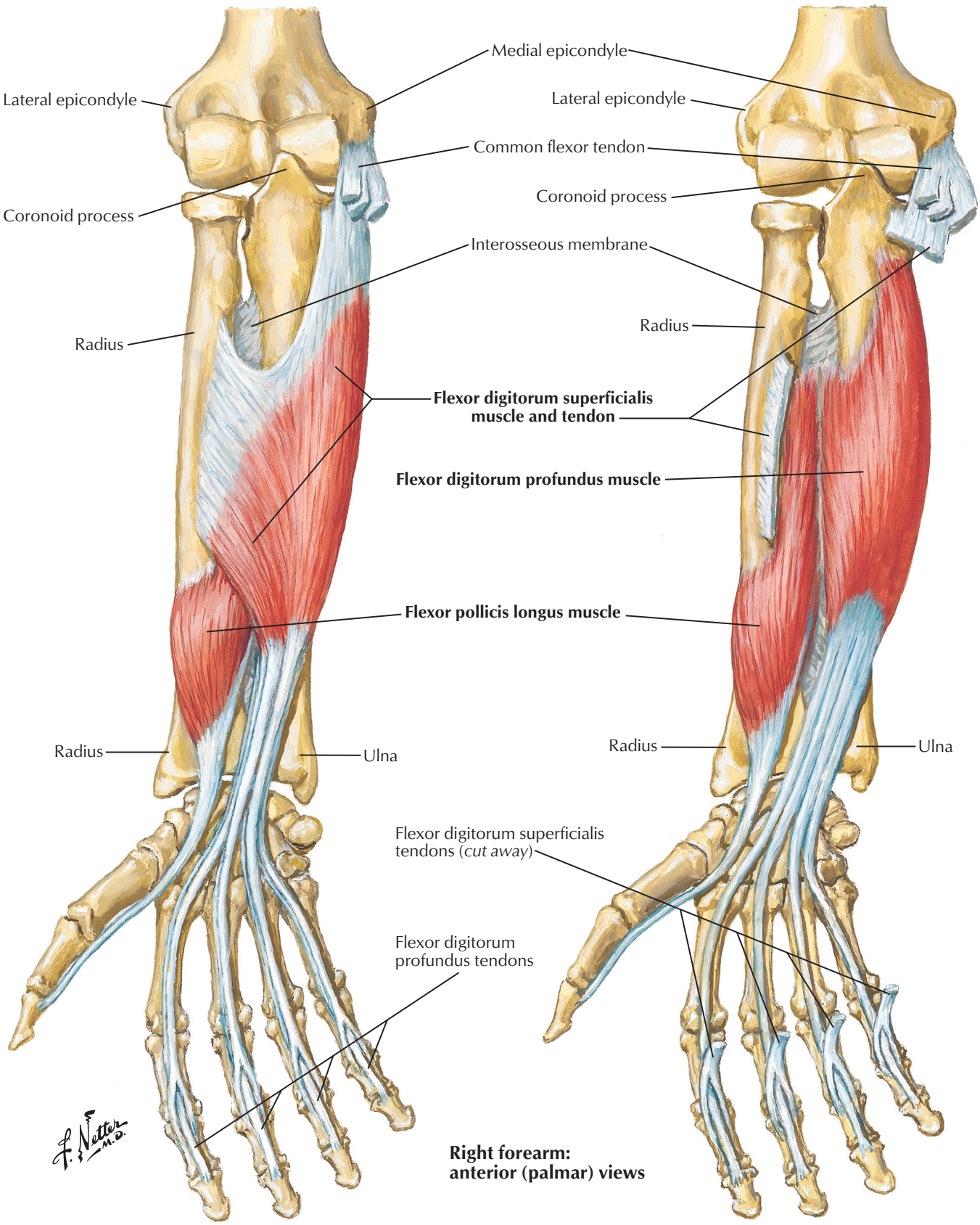
See also Plate 438



Note: Brachioradialis muscle not shown because it is flexor of elbow.



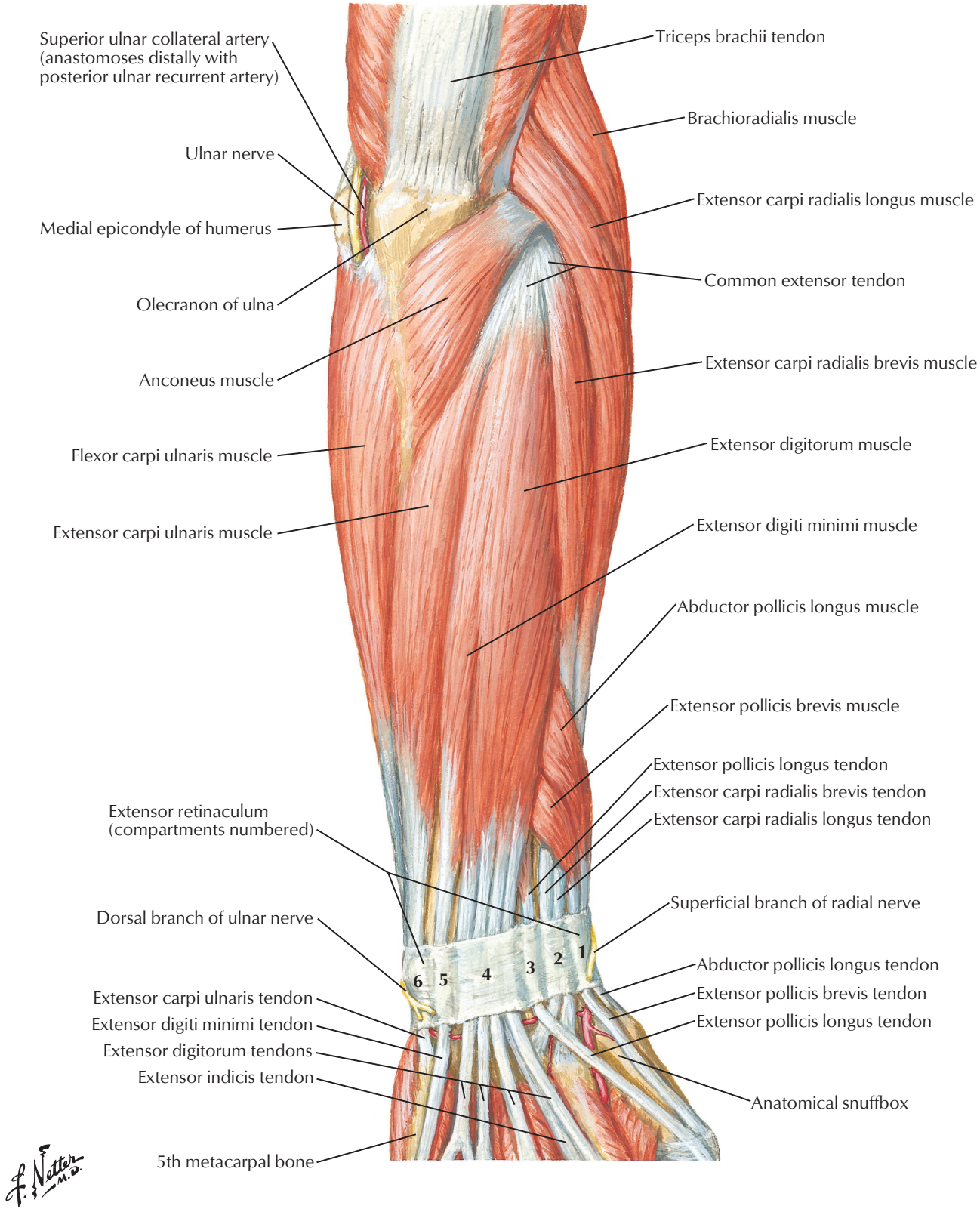
Right forearm: anterior (palmar) view



Right forearm: anterior (palmar) views

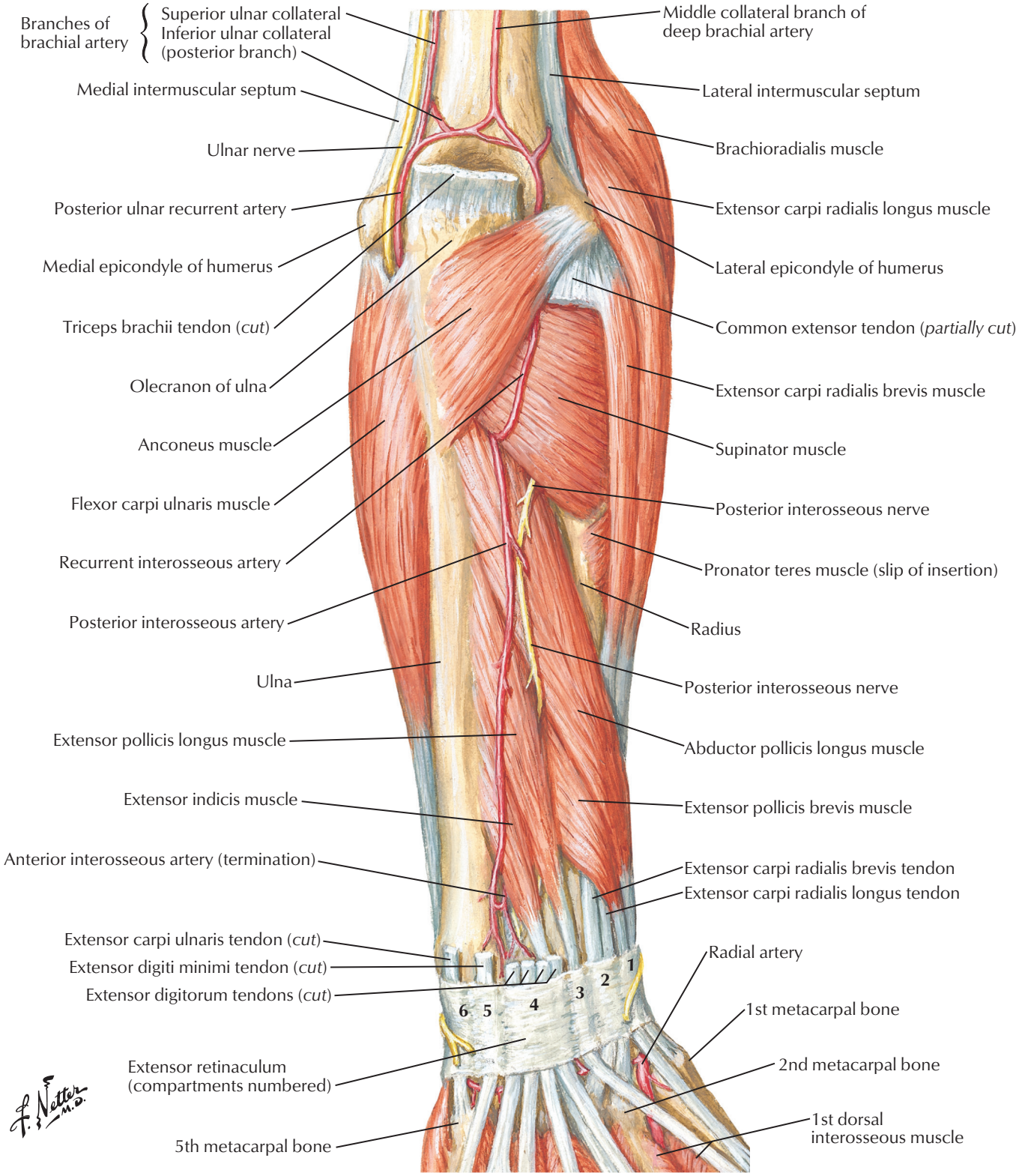
Muscles of Forearm (Superficial Layer): Posterior View

See also Plates 457, 466



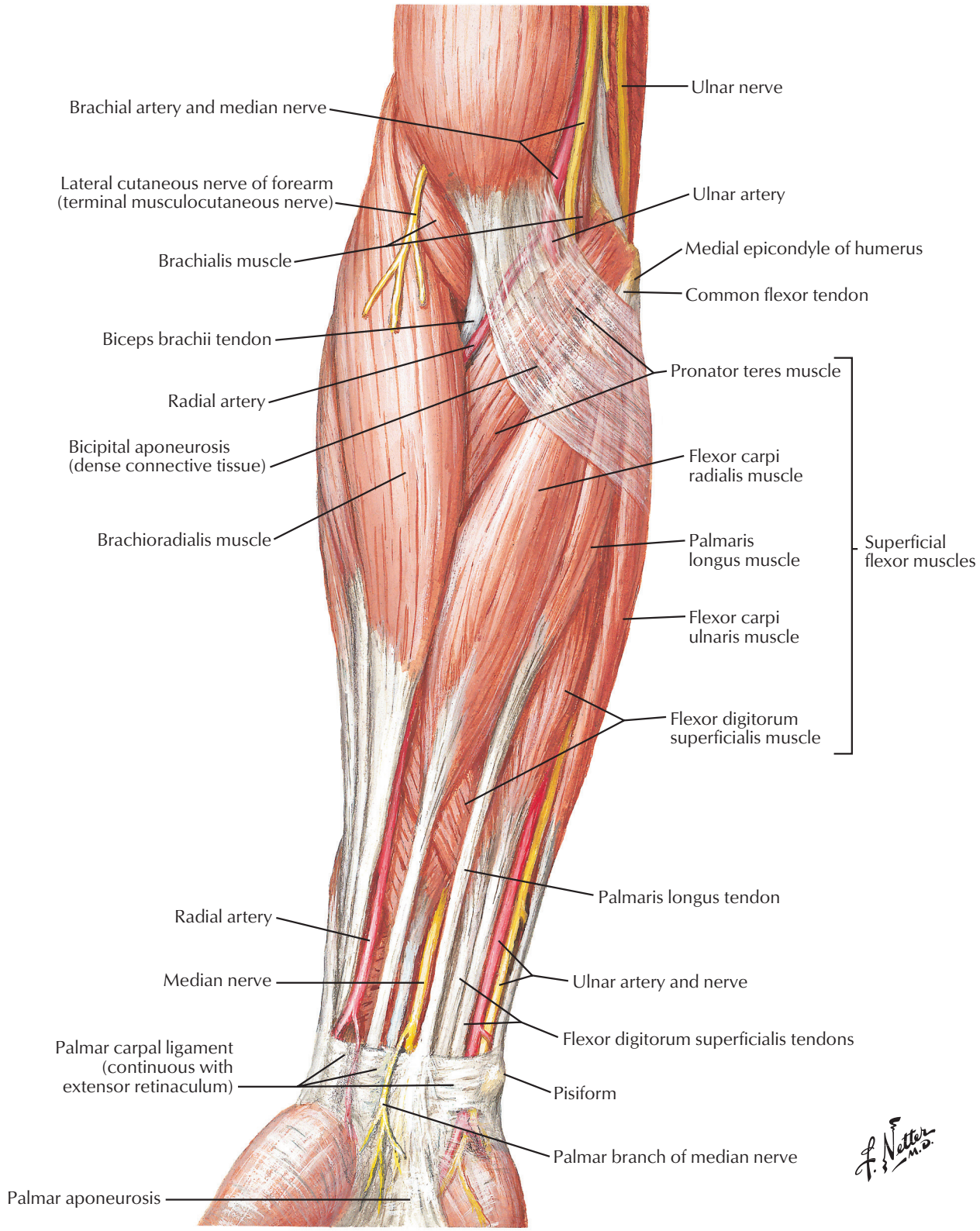
Muscles of Forearm (Deep Layer): Posterior View

See also Plates 402, 457



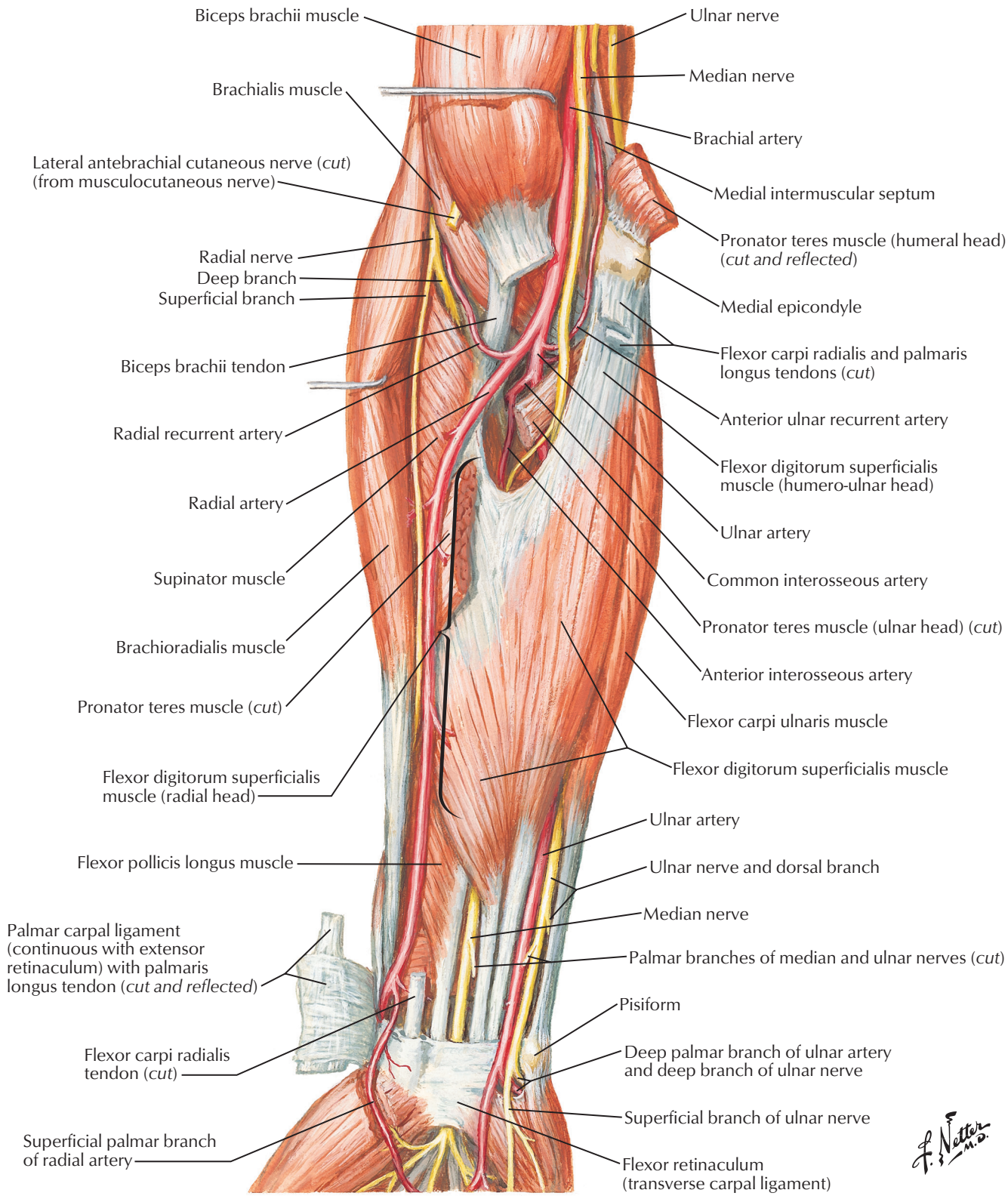
Muscles of Forearm (Superficial Layer): Anterior View

See also Plates 463, 464



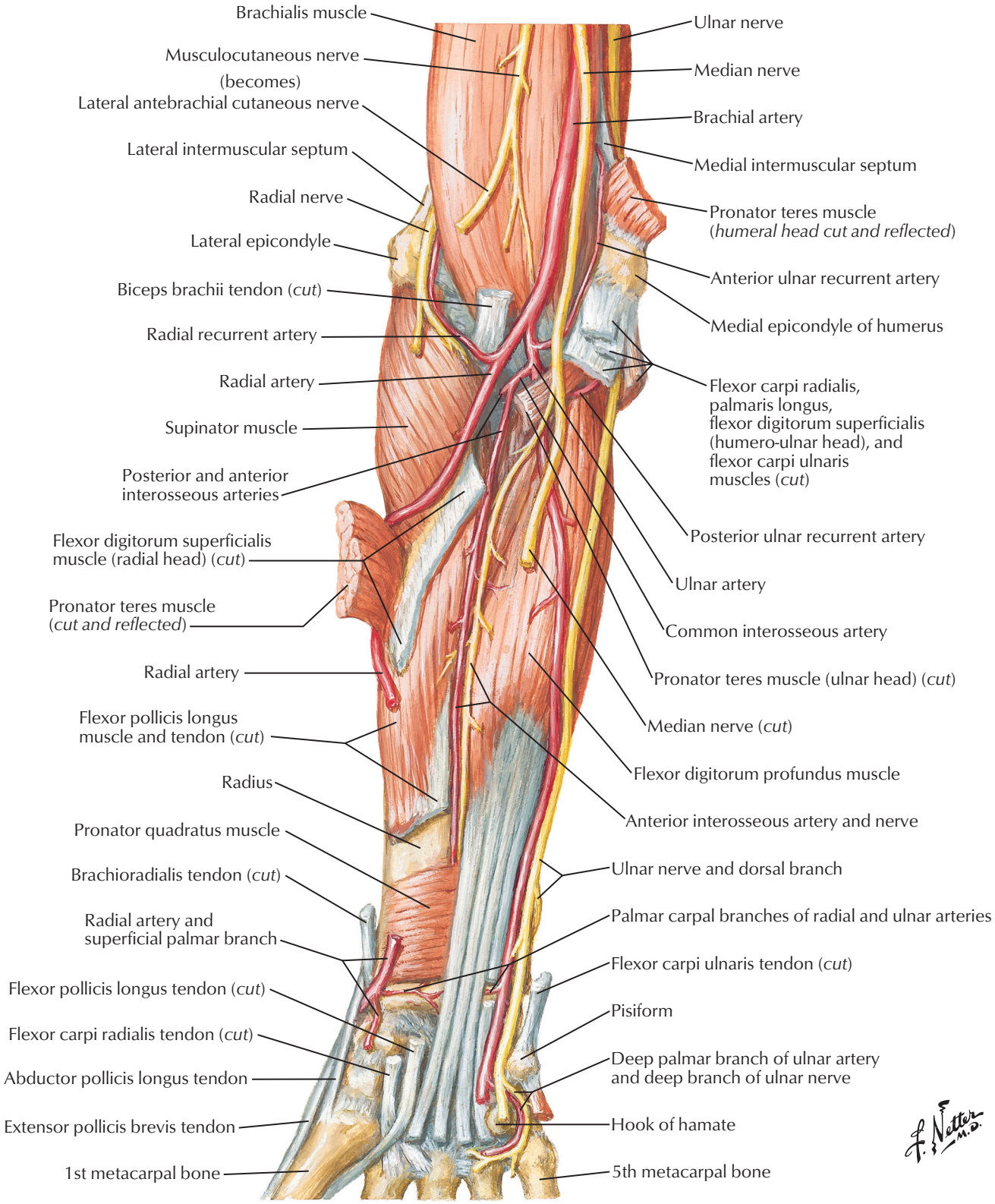
Muscles of Forearm (Intermediate Layer): Anterior View

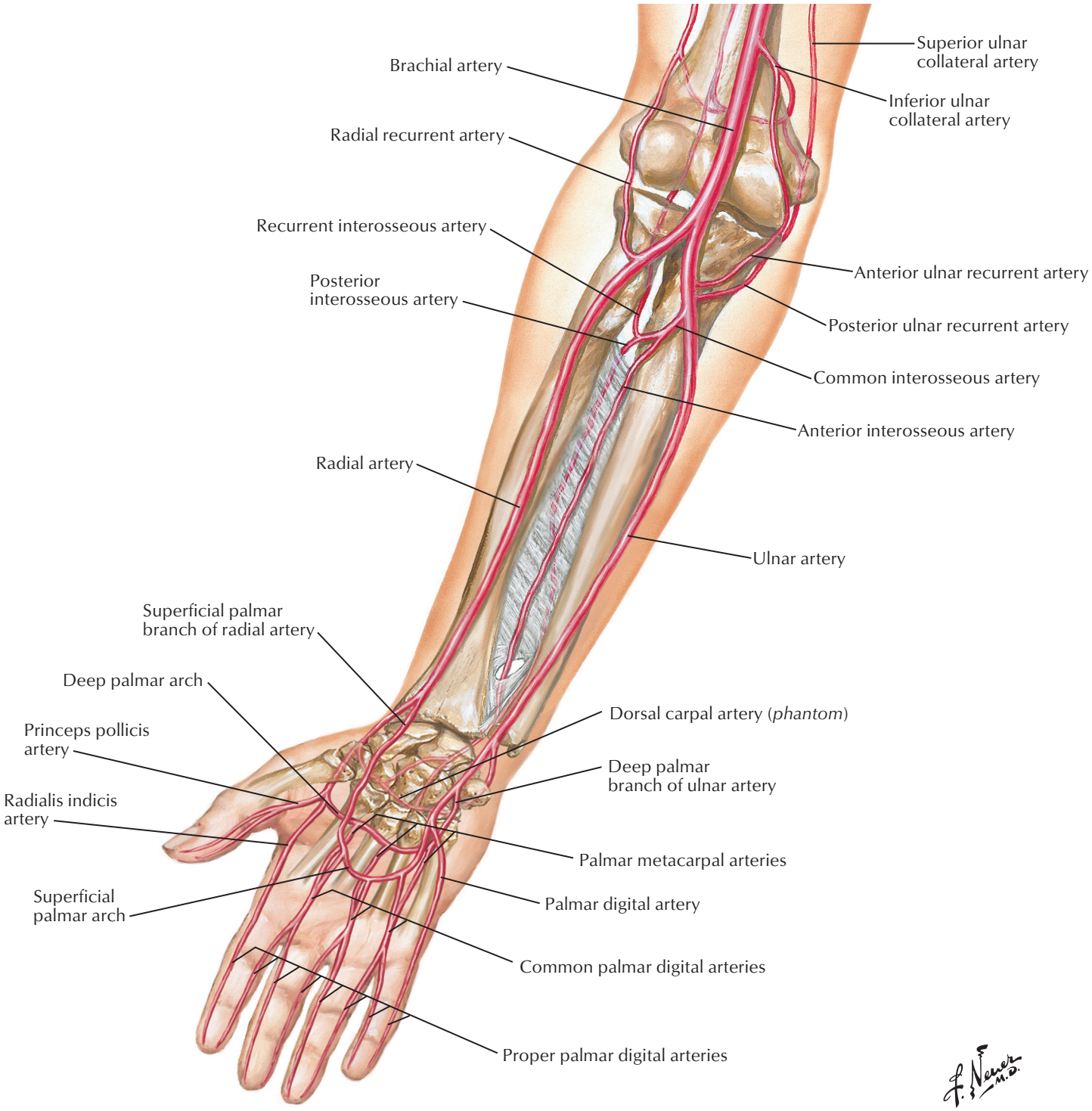
See also **Plates 420, 463, 464**

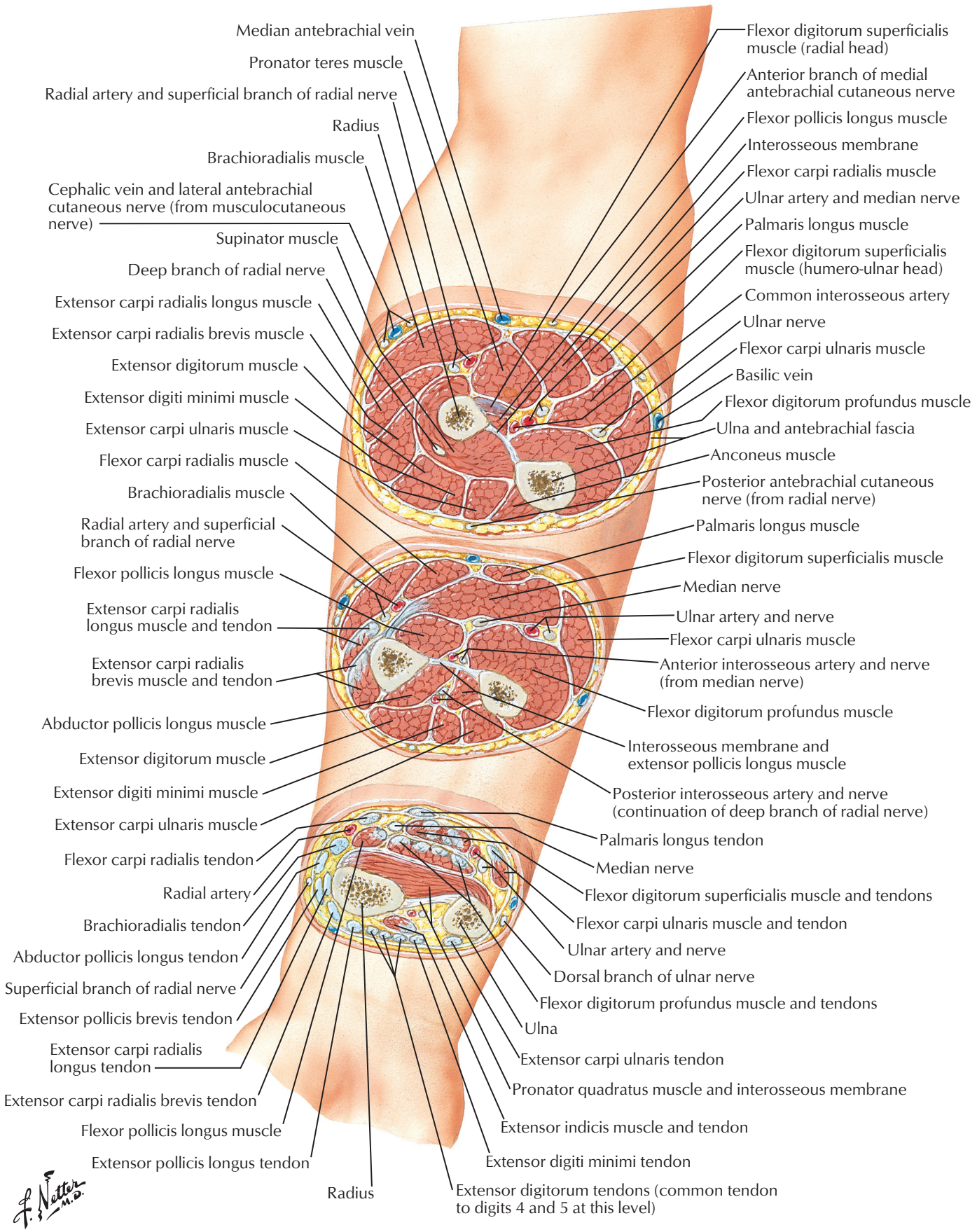


Muscles of Forearm (Deep Layer): Anterior View

See also Plates 426, 464

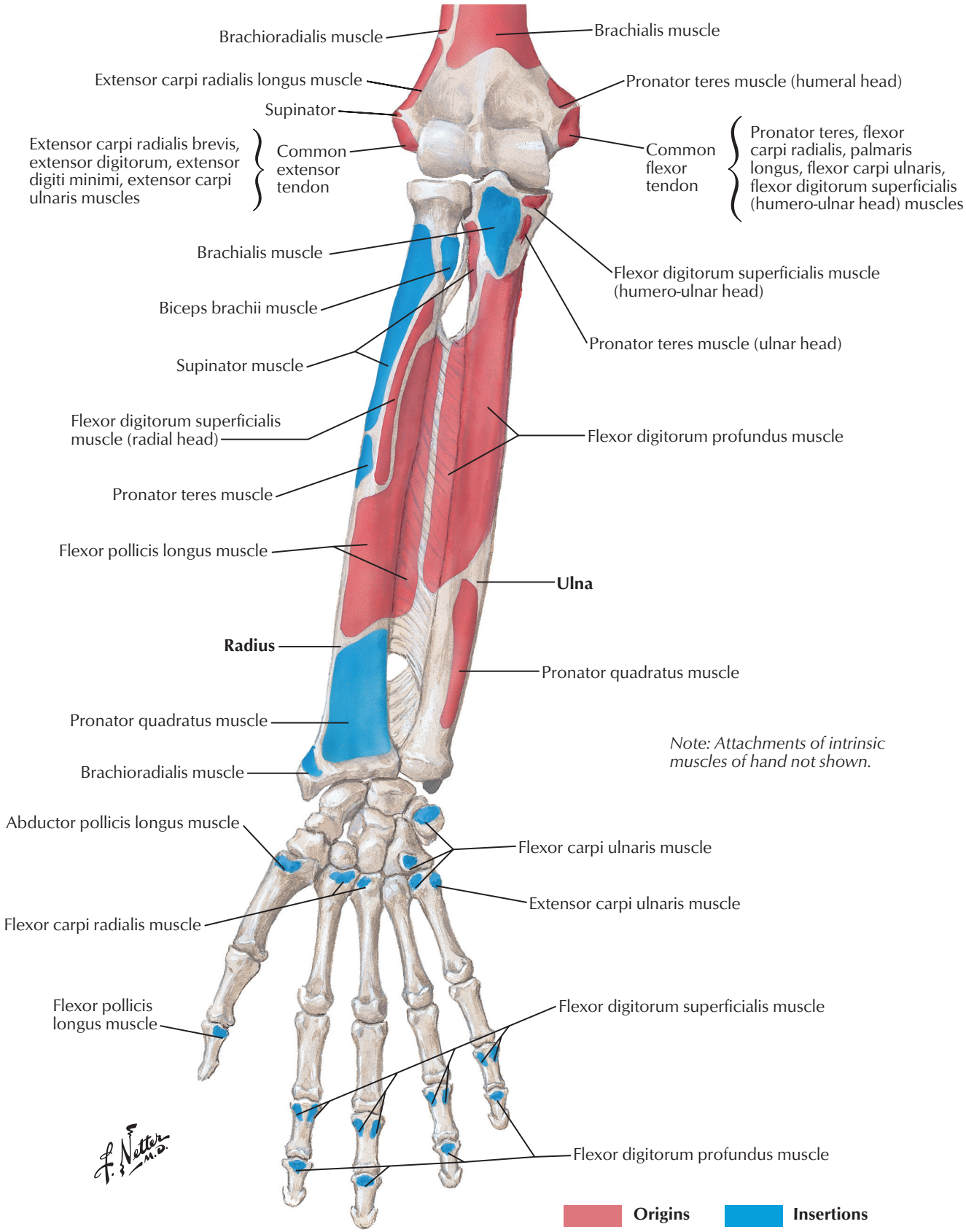



Brachial artery
Radial recurrent artery
Recurrent interosseous artery
Posterior interosseous artery
Radial artery
Superficial palmar branch of radial artery
Deep palmar arch
Princeps pollicis artery
Radialis indicis artery
Superficial palmar arch
Superior ulnar collateral artery
Inferior ulnar collateral artery
Anterior ulnar recurrent artery
Posterior ulnar recurrent artery
Common interosseous artery
Anterior interosseous artery
Ulnar artery
Dorsal carpal artery (phantom)
Deep palmar branch of ulnar artery
Palmar metacarpal arteries
Palmar digital artery
Common palmar digital arteries
Proper palmar digital arteries


Median antebrachial vein
Pronator teres muscle
Radial artery and superficial branch of radial nerve
Radius
Brachioradialis muscle
Cephalic vein and lateral antebrachial cutaneous nerve (from musculocutaneous nerve)
Supinator muscle
Deep branch of radial nerve
Extensor carpi radialis longus muscle
Extensor carpi radialis brevis muscle
Extensor digitorum muscle
Extensor digiti minimi muscle
Extensor carpi ulnaris muscle
Flexor carpi radialis muscle
Brachioradialis muscle
Radial artery and superficial branch of radial nerve
Flexor pollicis longus muscle
Extensor carpi radialis longus muscle and tendon
Extensor carpi radialis brevis muscle and tendon
Abductor pollicis longus muscle
Extensor digitorum muscle
Extensor digiti minimi muscle
Extensor carpi ulnaris muscle
Flexor carpi radialis tendon
Radial artery
Brachioradialis tendon
Abductor pollicis longus tendon
Superficial branch of radial nerve
Extensor pollicis brevis tendon
Extensor carpi radialis longus tendon
Extensor carpi radialis brevis tendon
Flexor pollicis longus muscle
Extensor pollicis longus tendon
Radius
Flexor digitorum superficialis muscle (radial head)
Anterior branch of medial antebrachial cutaneous nerve
Flexor pollicis longus muscle
Interosseous membrane
Flexor carpi radialis muscle
Ulnar artery and median nerve
Palmaris longus muscle
Flexor digitorum superficialis muscle (humero-ulnar head)
Common interosseous artery
Ulnar nerve
Flexor carpi ulnaris muscle
Basilic vein
Flexor digitorum profundus muscle
Ulna and antebrachial fascia
Anconeus muscle
Posterior antebrachial cutaneous nerve (from radial nerve)
Palmaris longus muscle
Flexor digitorum superficialis muscle
Median nerve
Ulnar artery and nerve
Flexor carpi ulnaris muscle
Anterior interosseous artery and nerve (from median nerve)
Flexor digitorum profundus muscle
Interosseous membrane and extensor pollicis longus muscle
Posterior interosseous artery and nerve (continuation of deep branch of radial nerve)
Palmaris longus tendon
Median nerve
Flexor digitorum superficialis muscle and tendons
Flexor carpi ulnaris muscle and tendon
Ulnar artery and nerve
Dorsal branch of ulnar nerve
Flexor digitorum profundus muscle and tendons
Ulna
Extensor carpi ulnaris tendon
Pronator quadratus muscle and interosseous membrane
Extensor indicis muscle and tendon
Extensor digiti minimi tendon
Extensor digitorum tendons (common tendon to digits 4 and 5 at this level)

Attachments of Muscles of Forearm: Anterior View

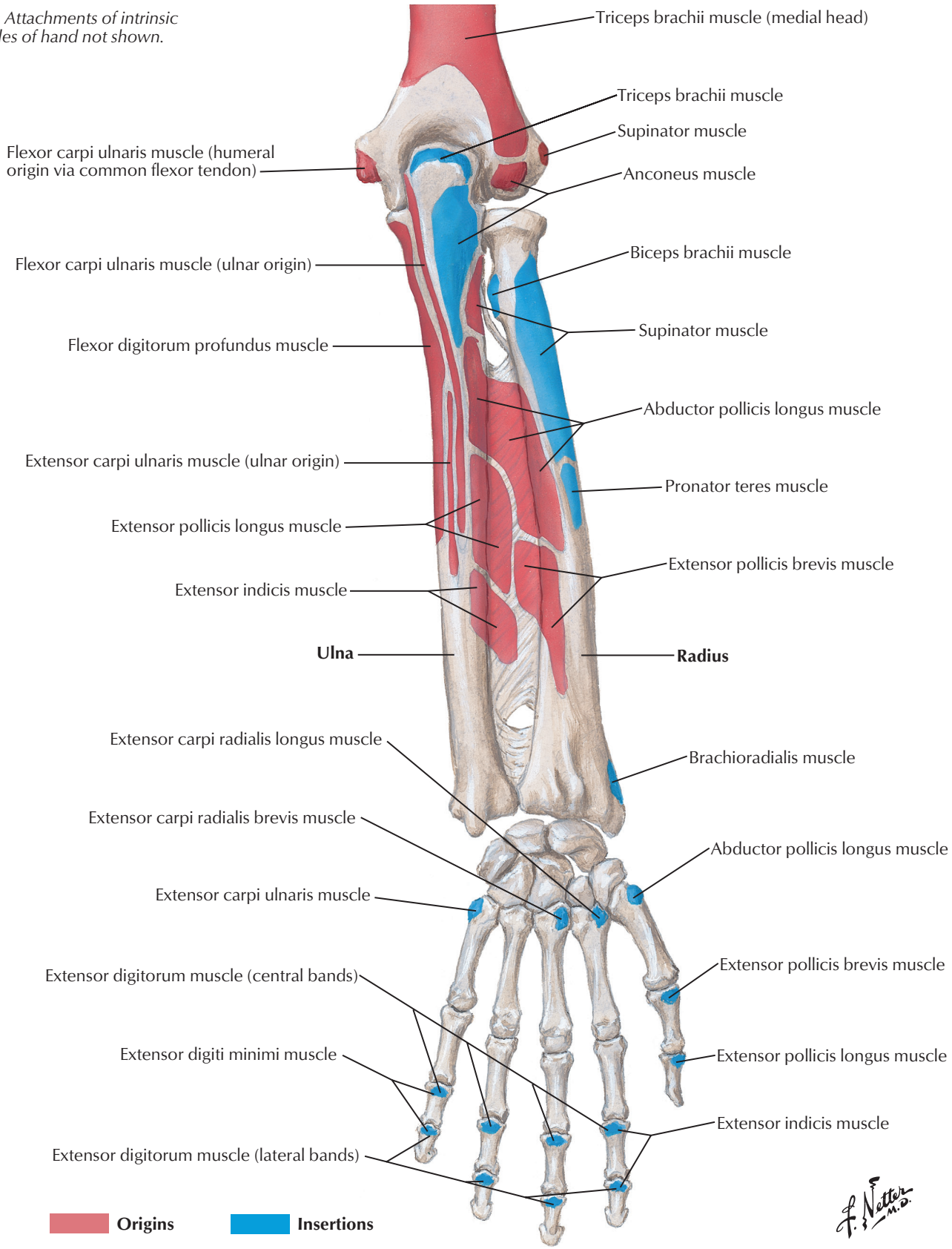
See also Plate 422



Attachments of Muscles of Forearm: Posterior View

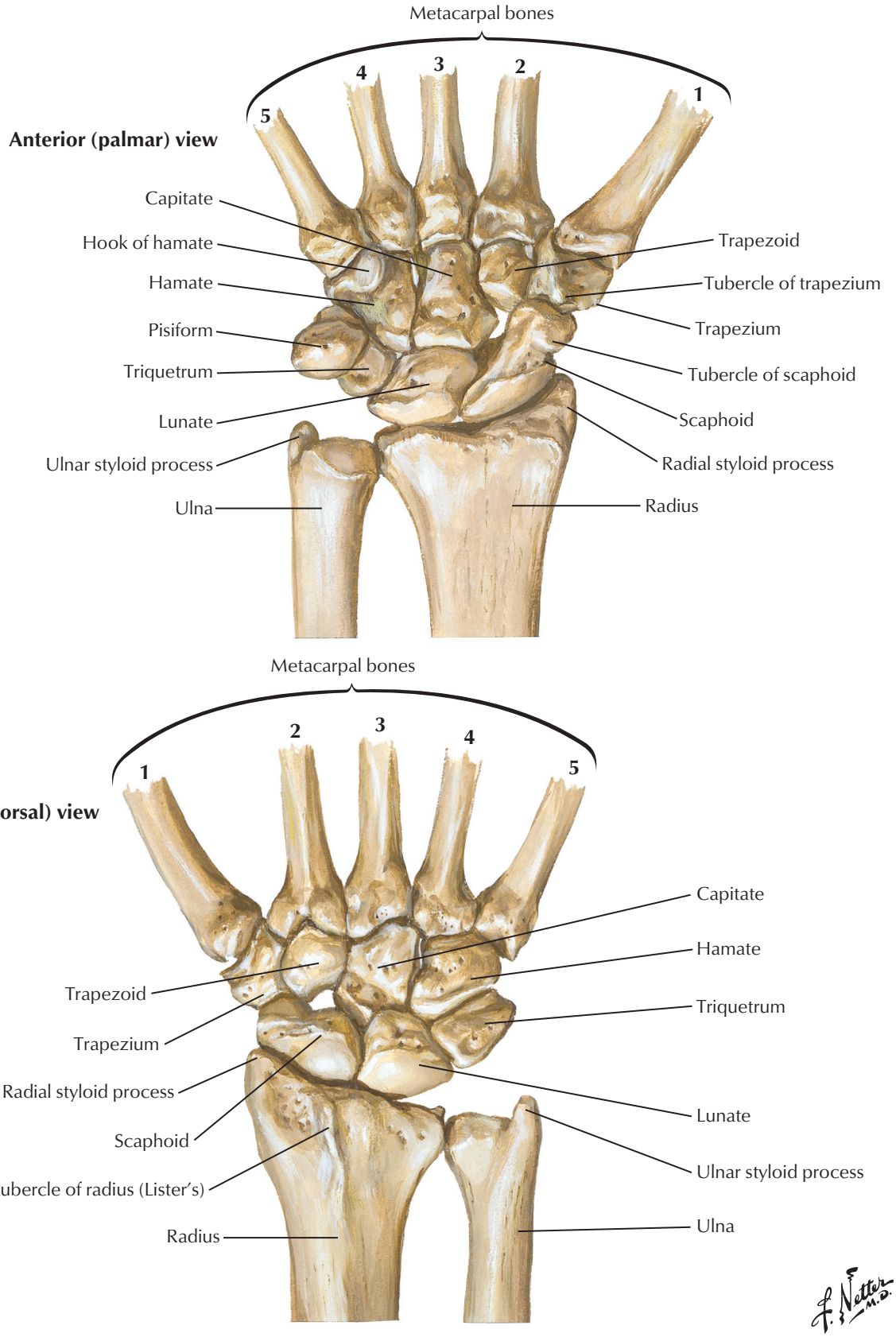
See also Plate 427

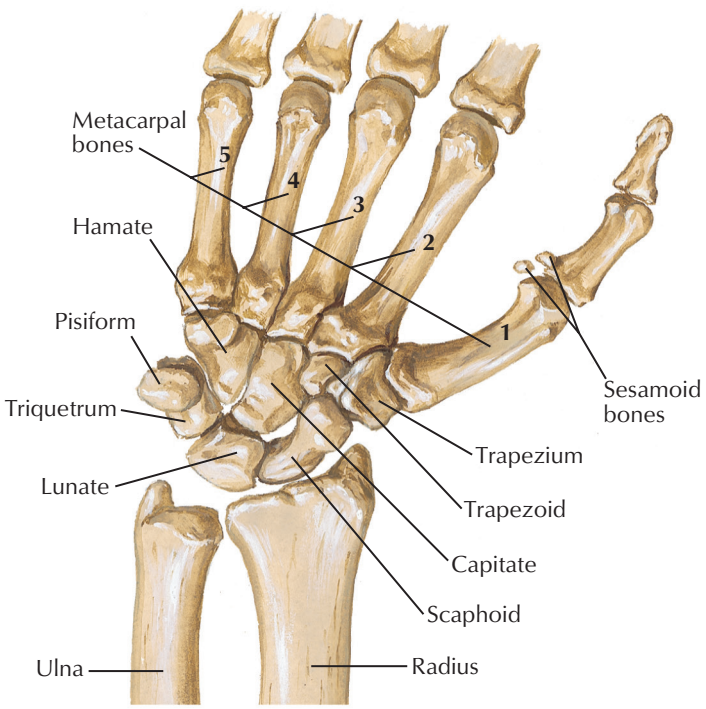
Note: Attachments of intrinsic muscles of hand not shown.



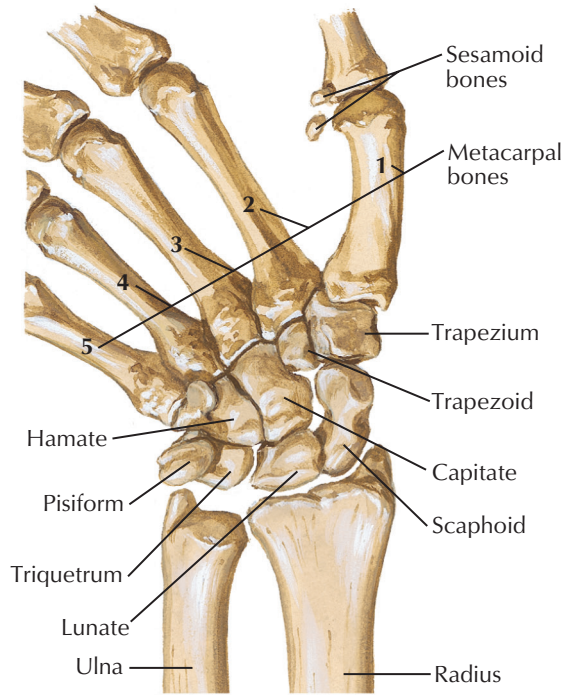
Carpal Bones

See also Plate 425

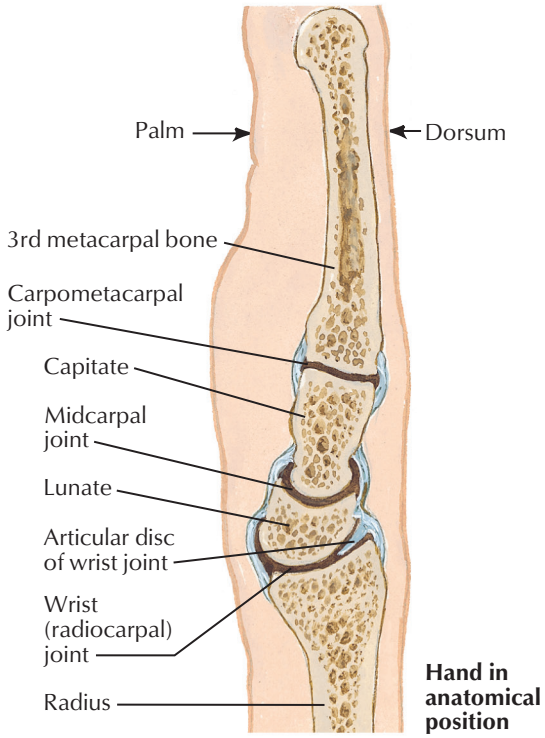




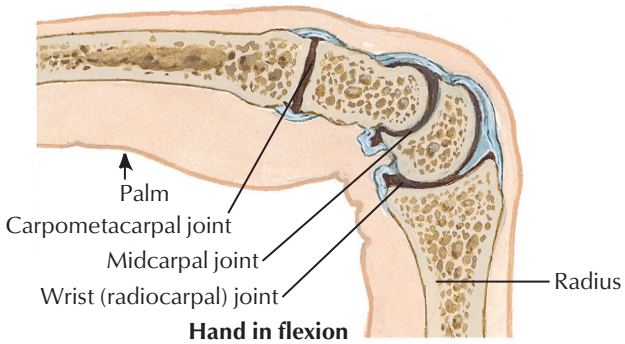
Position of carpal bones with hand in abduction: anterior (palmar) view

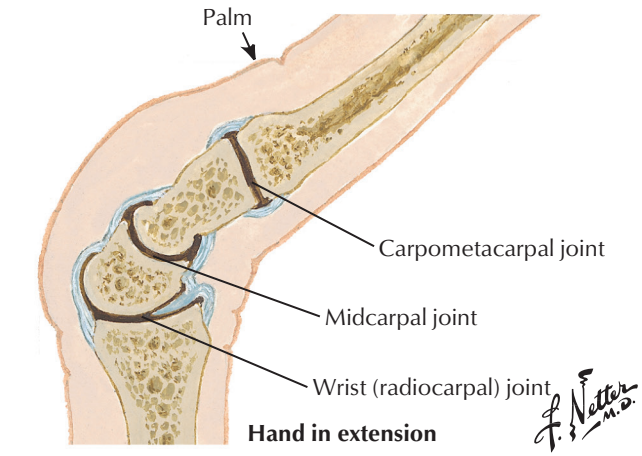


Position of carpal bones with hand in adduction: anterior (palmar) view

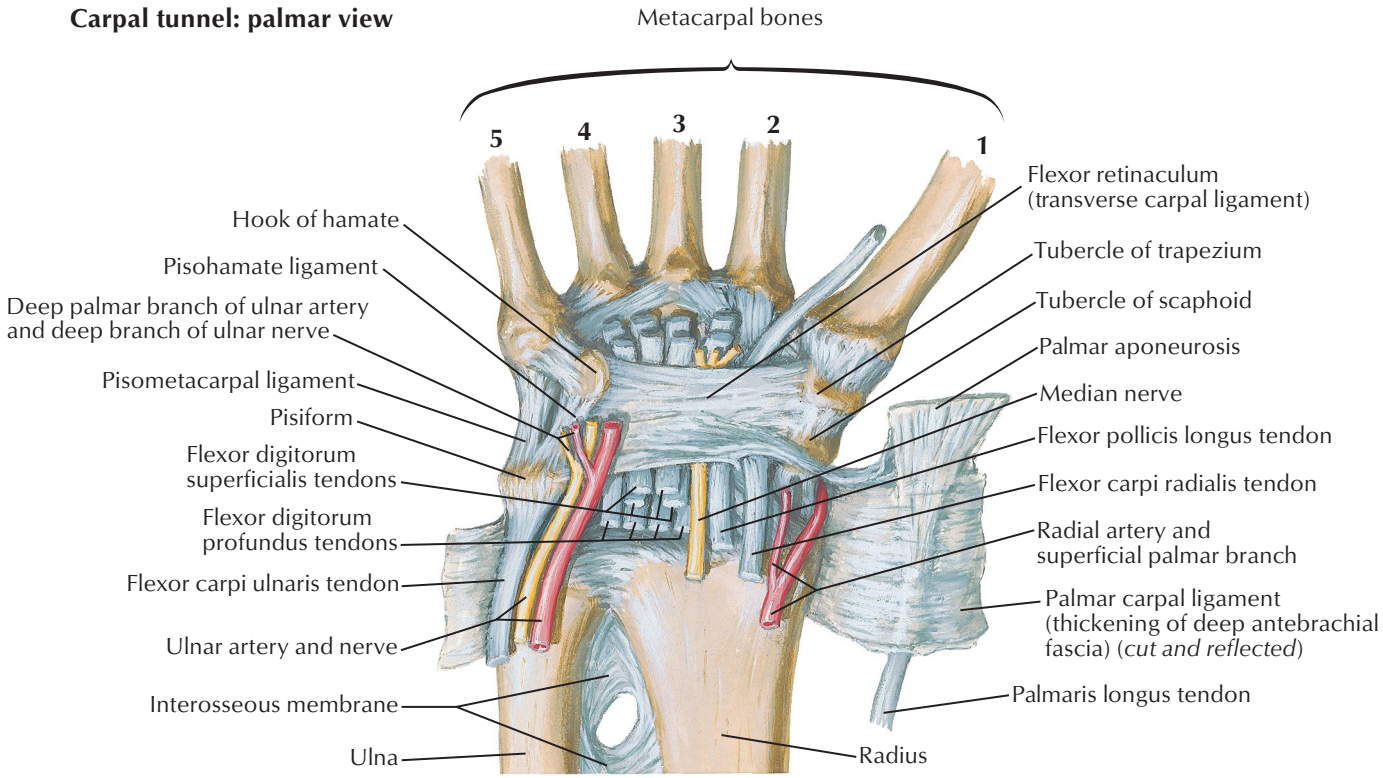


Sagittal sections through wrist and middle finger

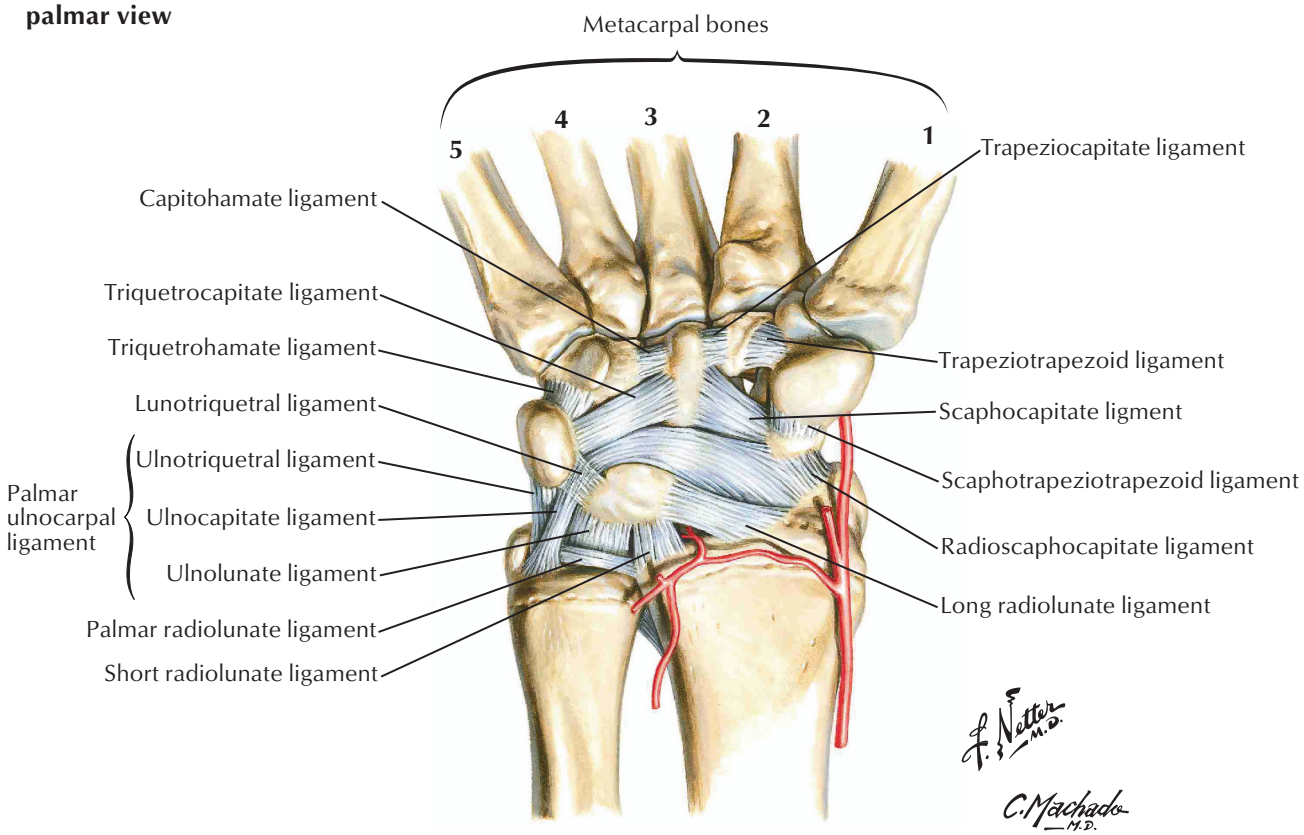




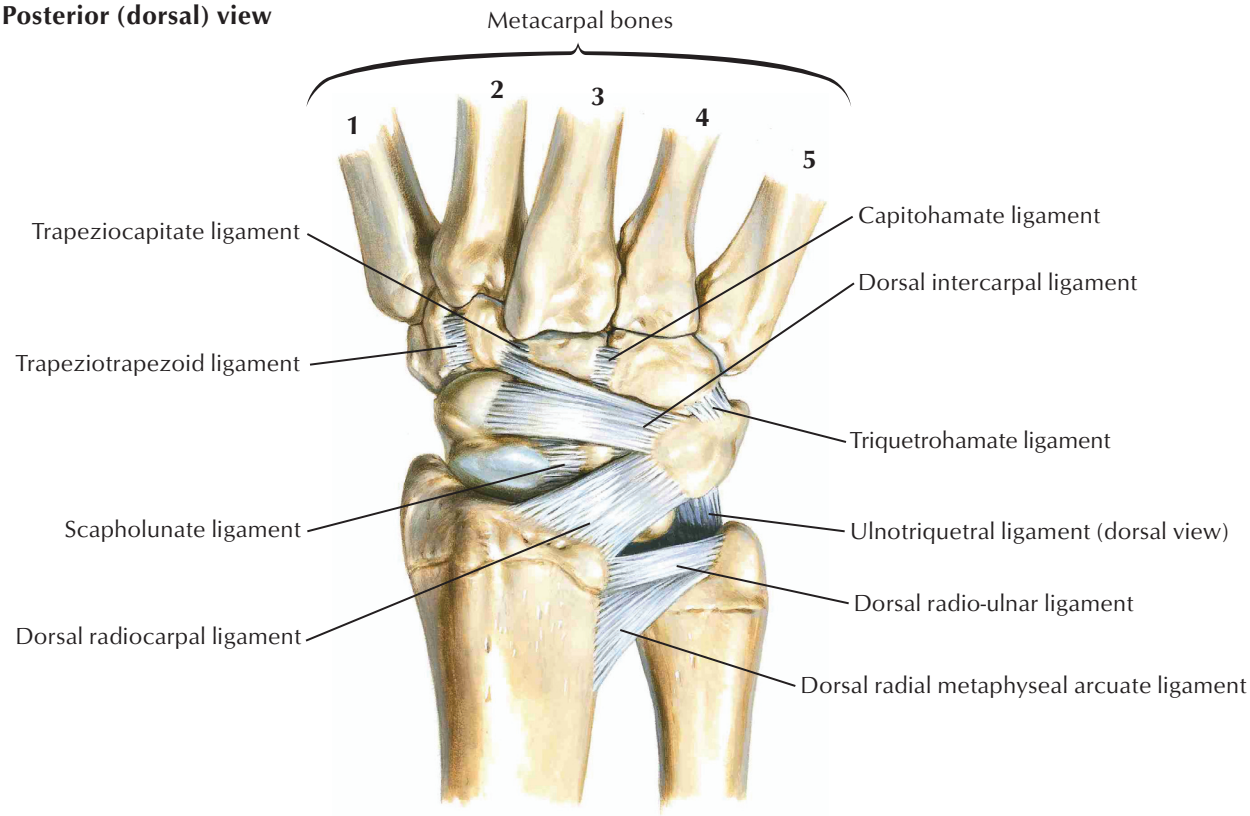
Carpal tunnel: palmar view



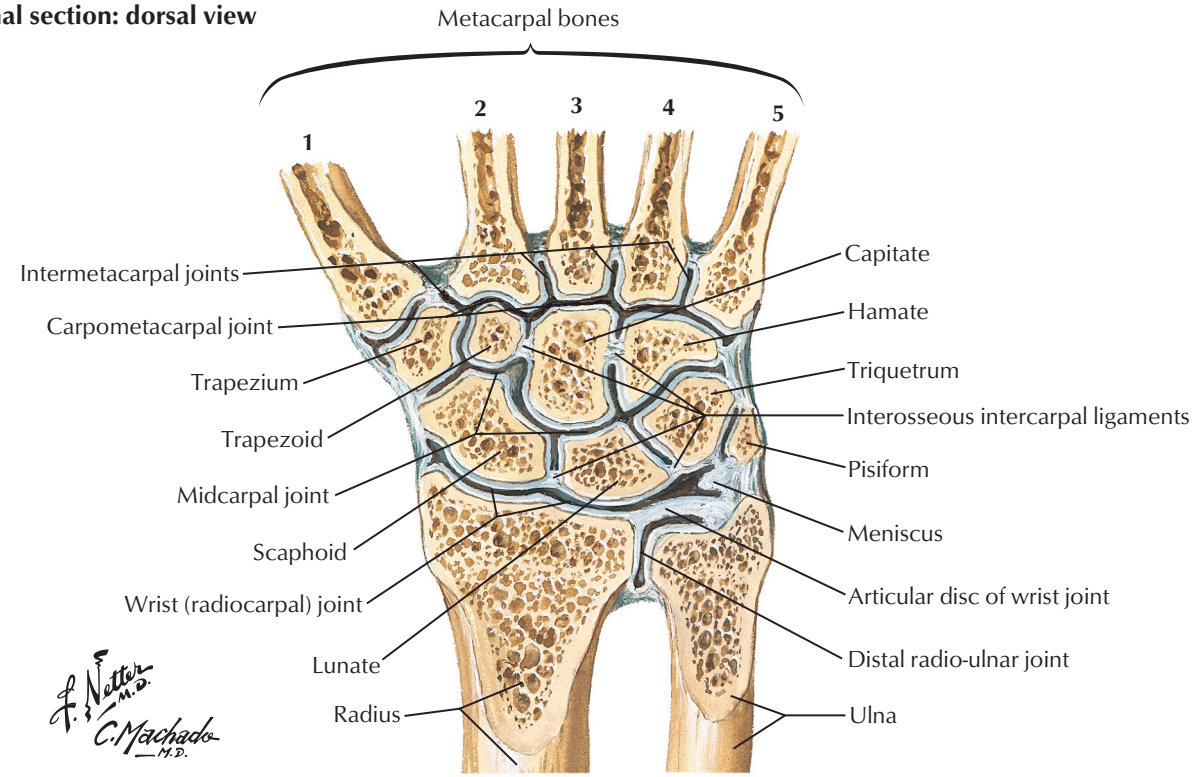
Flexor retinaculum removed: palmar view

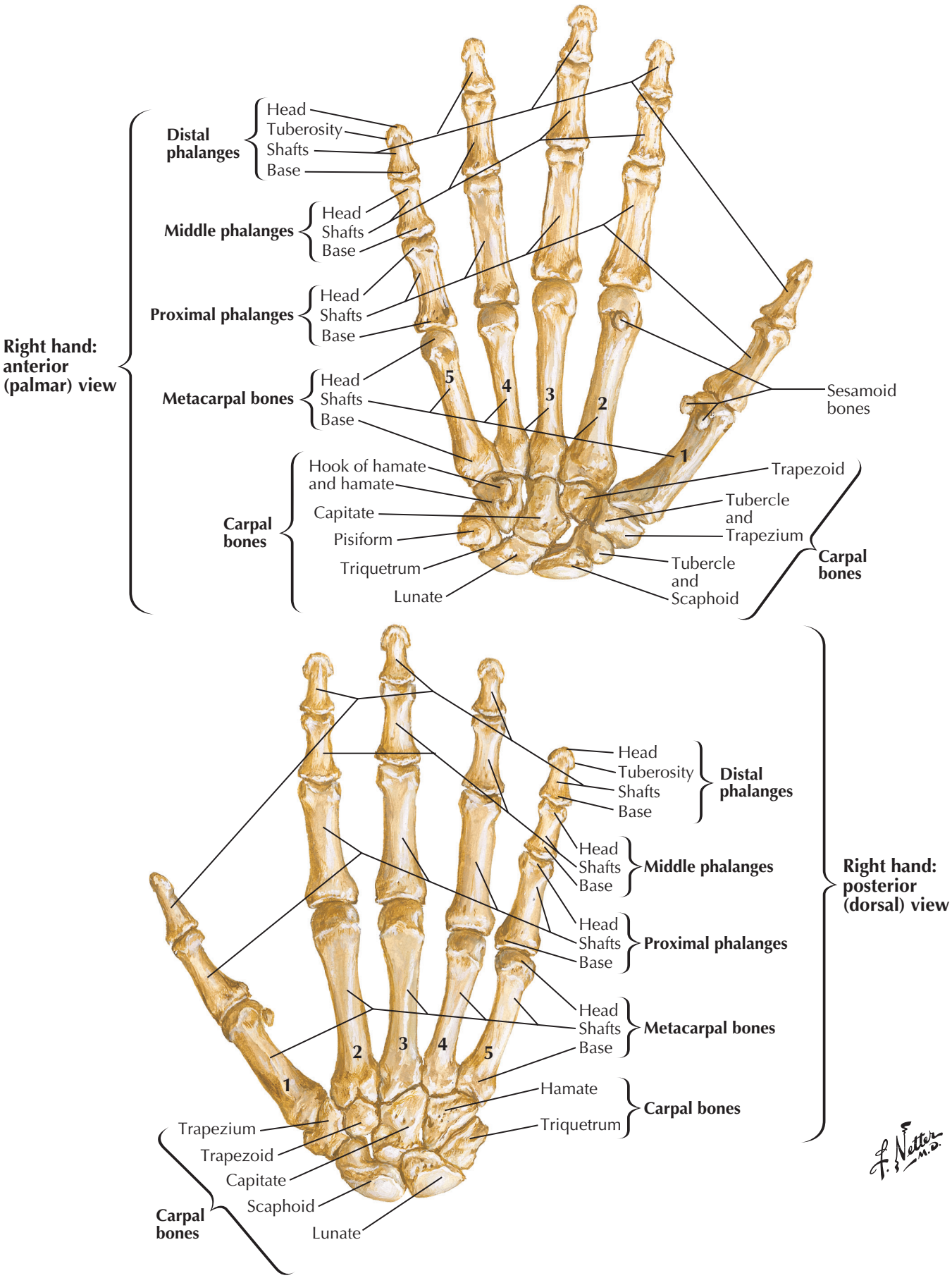


Posterior (dorsal) view



Coronal section: dorsal view




Right hand: anterior (palmar) view
Distal phalanges
Head
Tuberosity
Shafts
Base
Middle phalanges
Head
Shafts
Base
Proximal phalanges
Head
Shafts
Base
Metacarpal bones
Head
Shafts
Base
5
4
3
2
1
Sesamoid bones
Carpal bones
Hook of hamate and hamate
Capitate
Pisiform
Triquetrum
Lunate
Trapezoid
Tubercle and Trapezium
Tubercle and Scaphoid
Carpal bones
Right hand: posterior (dorsal) view
Distal phalanges
Head
Tuberosity
Shafts
Base
Middle phalanges
Head
Shafts
Base
Proximal phalanges
Head
Shafts
Base
Metacarpal bones
Head
Shafts
Base
1
2
3
4
5
Carpal bones
Hamate
Triquetrum
Trapezium
Trapezoid
Capitate
Scaphoid
Lunate
Carpal bones

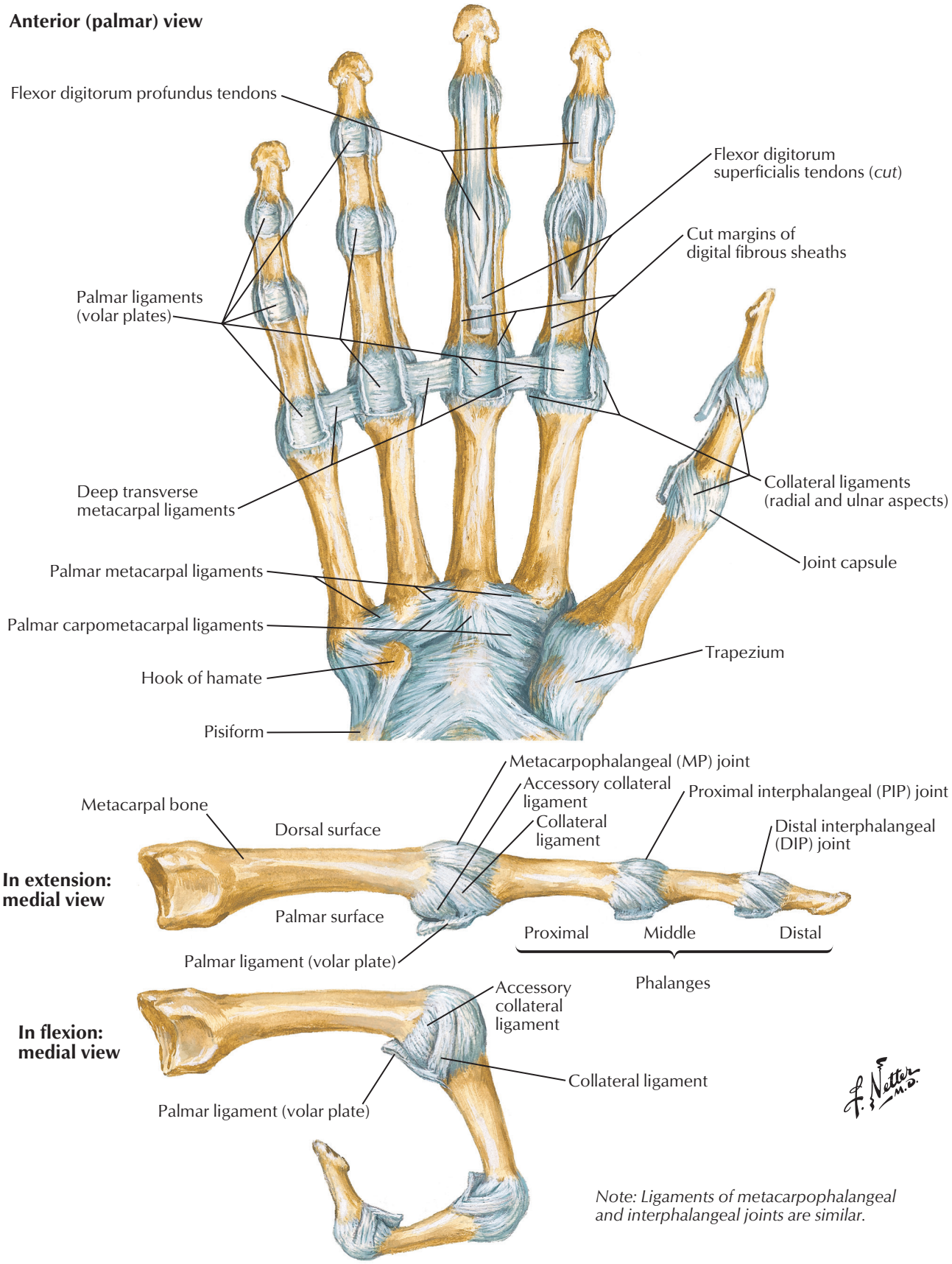
See also Plate 456

Anteroposterior view

Lateral view

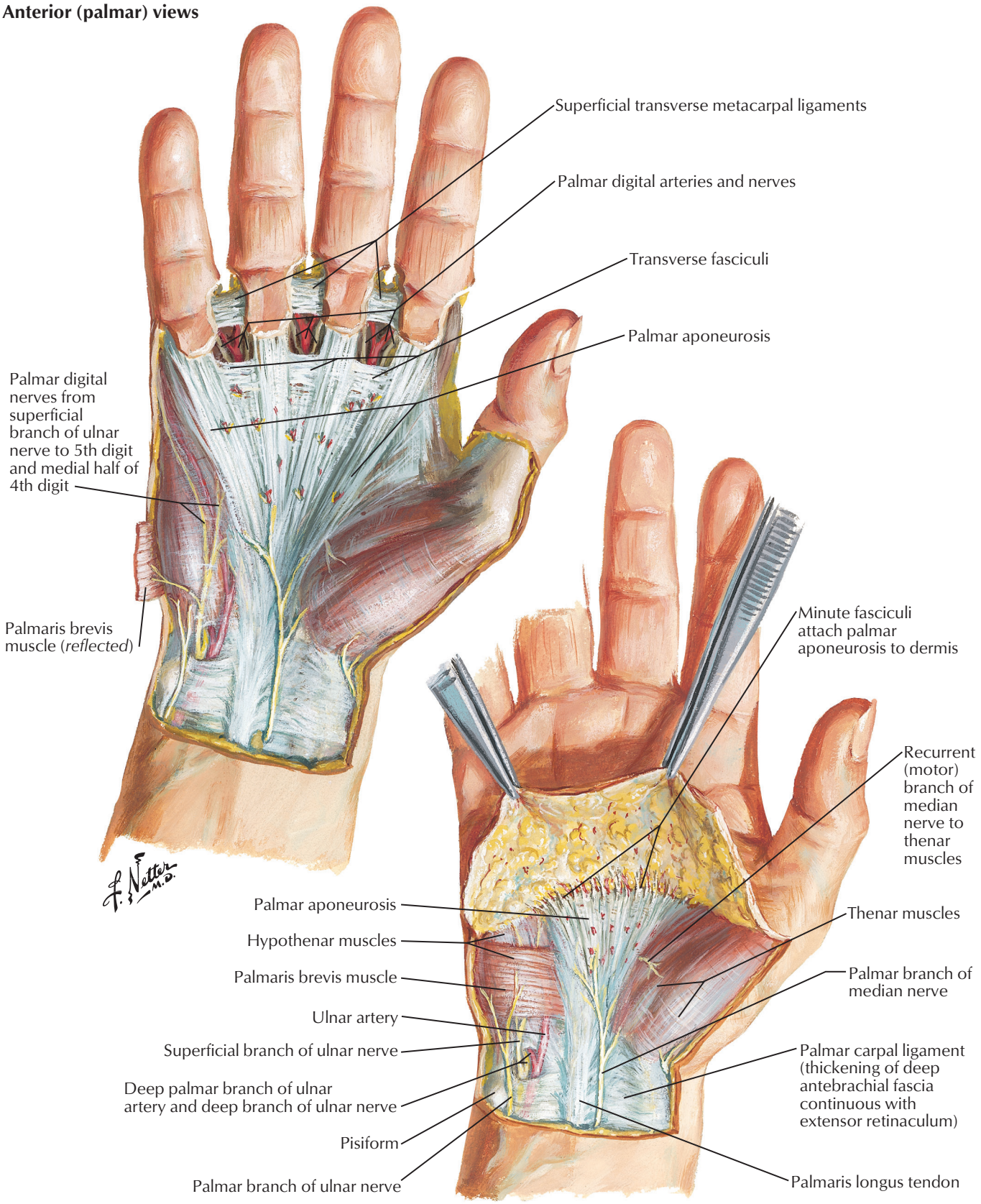
Metacarpophalangeal and Interphalangeal Ligaments

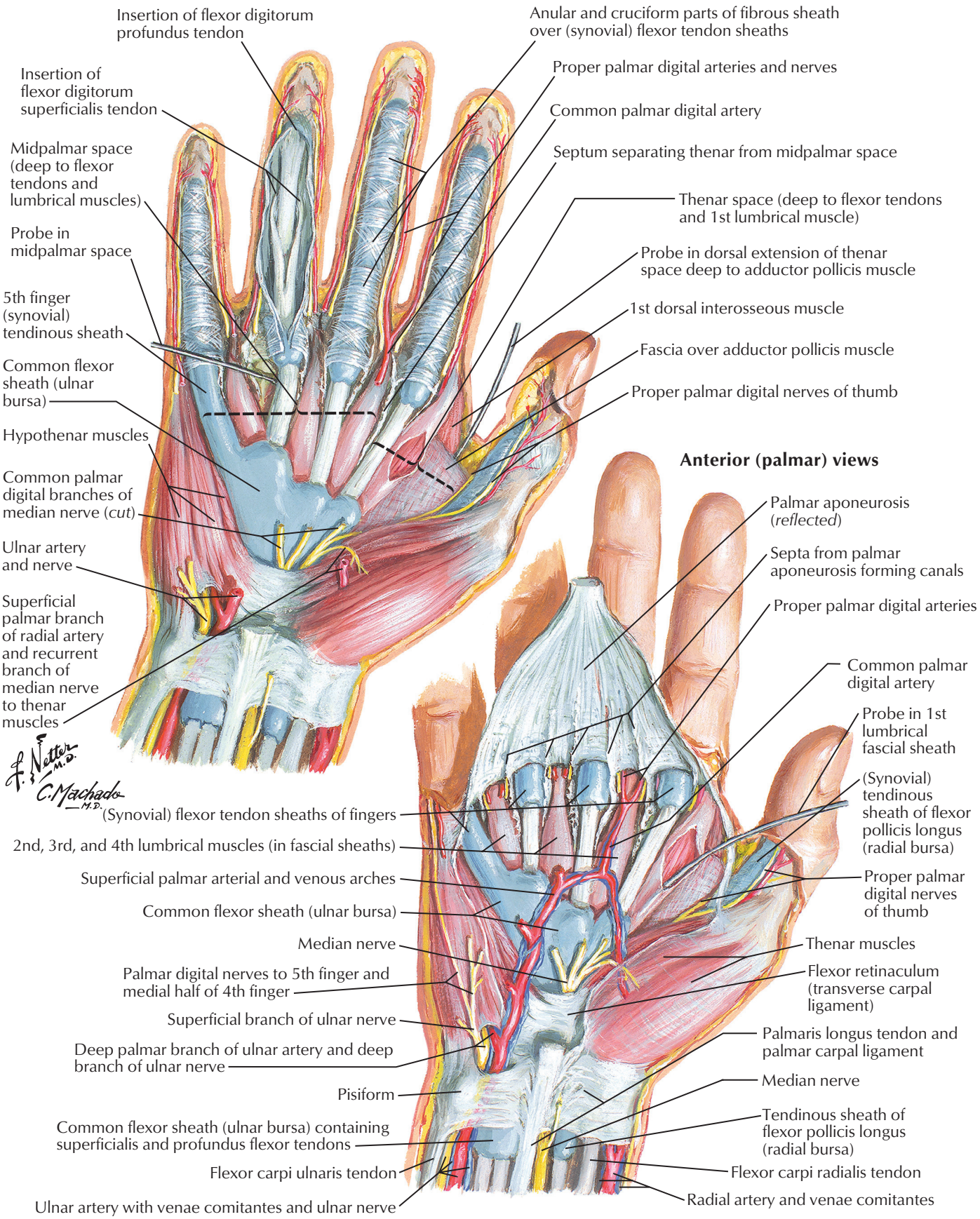
See also **Plates 448, 451**



Note: Ligaments of metacarpophalangeal and interphalangeal joints are similar.

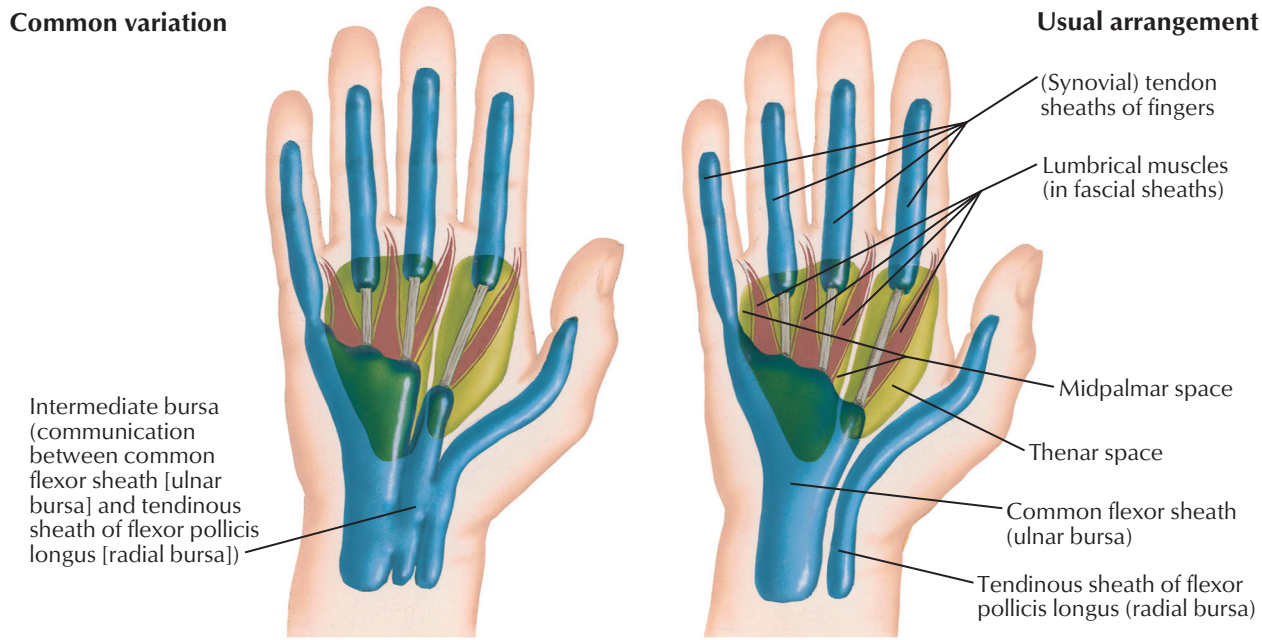
Anterior (palmar) views



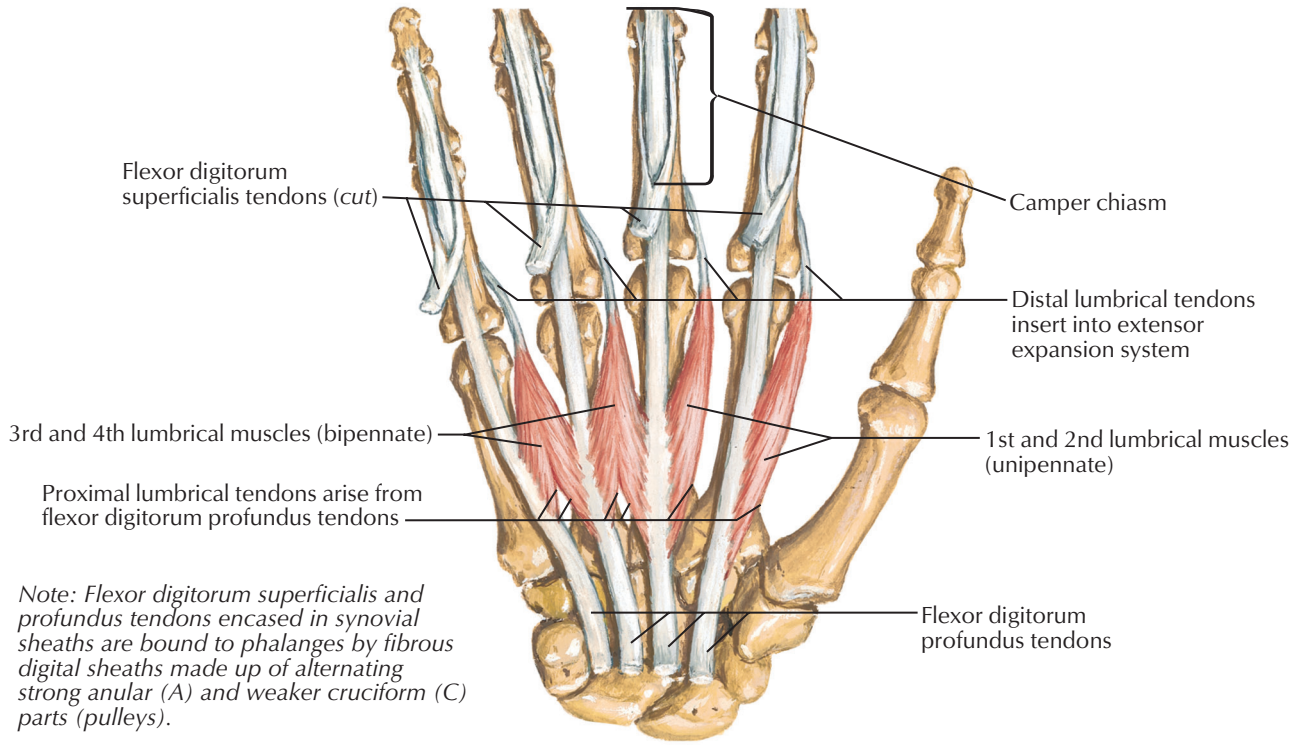

Insertion of flexor digitorum profundus tendon
Insertion of flexor digitorum superficialis tendon
Midpalmar space (deep to flexor tendons and lumbrical muscles)
Probe in midpalmar space
5th finger (synovial) tendinous sheath
Common flexor sheath (ulnar bursa)
Hypothenar muscles
Common palmar digital branches of median nerve (cut)
Ulnar artery and nerve
Superficial palmar branch of radial artery and recurrent branch of median nerve to thenar muscles
Anular and cruciform parts of fibrous sheath over (synovial) flexor tendon sheaths
Proper palmar digital arteries and nerves
Common palmar digital artery
Septum separating thenar from midpalmar space
Thenar space (deep to flexor tendons and 1st lumbrical muscle)
Probe in dorsal extension of thenar space deep to adductor pollicis muscle
1st dorsal interosseous muscle
Fascia over adductor pollicis muscle
Proper palmar digital nerves of thumb
F. Netter M.D.
C. Machado M.D.
Anterior (palmar) views
Palmar aponeurosis (reflected)
Septa from palmar aponeurosis forming canals
Proper palmar digital arteries
Common palmar digital artery
Probe in 1st lumbrical fascial sheath
(Synovial) tendinous sheath of flexor pollicis longus (radial bursa)
Proper palmar digital nerves of thumb
Thenar muscles
Flexor retinaculum (transverse carpal ligament)
Palmaris longus tendon and palmar carpal ligament
Median nerve
Tendinous sheath of flexor pollicis longus (radial bursa)
Flexor carpi radialis tendon
Radial artery and venae comitantes
(Synovial) flexor tendon sheaths of fingers
2nd, 3rd, and 4th lumbrical muscles (in fascial sheaths)
Superficial palmar arterial and venous arches
Common flexor sheath (ulnar bursa)
Median nerve
Palmar digital nerves to 5th finger and medial half of 4th finger
Superficial branch of ulnar nerve
Deep palmar branch of ulnar artery and deep branch of ulnar nerve
Pisiform
Common flexor sheath (ulnar bursa) containing superficialis and profundus flexor tendons
Flexor carpi ulnaris tendon
Ulnar artery with venae comitantes and ulnar nerve

Lumbrical Muscles and Bursae, Spaces, and Sheaths: Schema

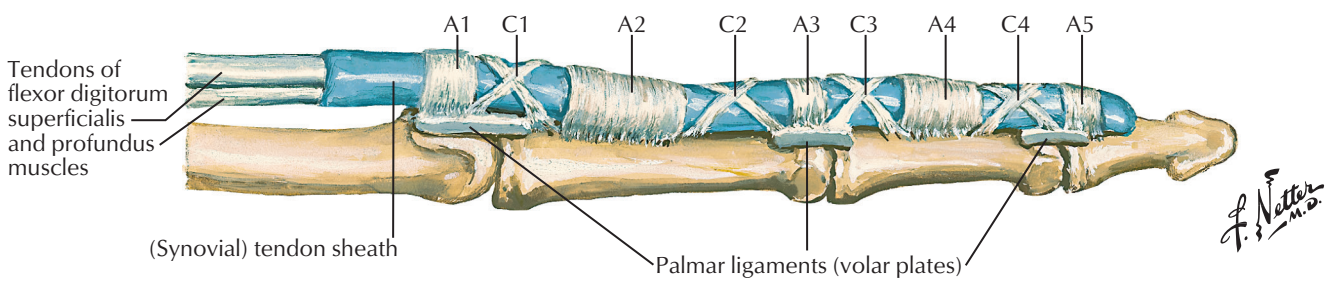
See also **Plate 445**



Lumbrical muscles: schema



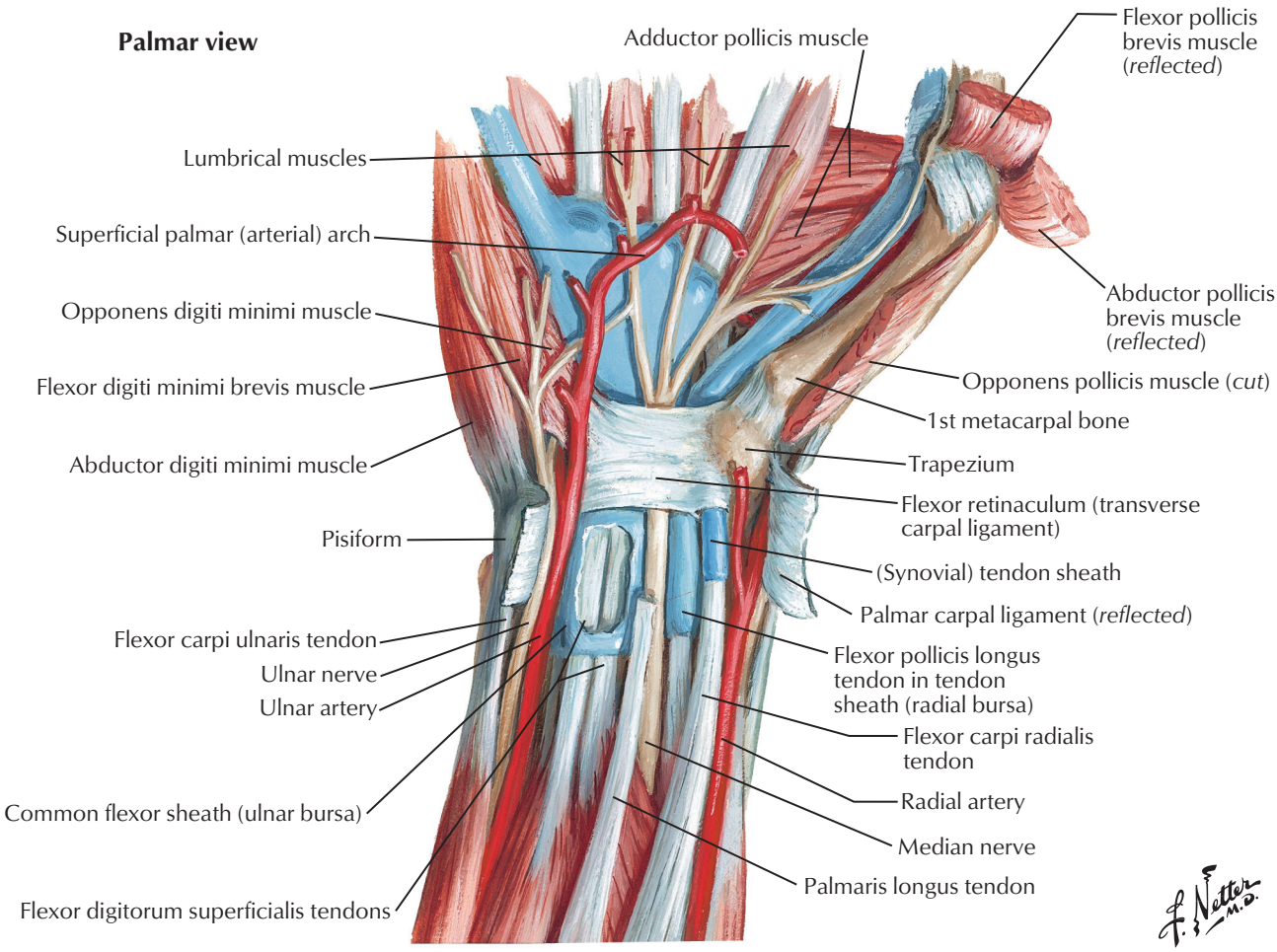
Note: Flexor digitorum superficialis and profundus tendons encased in synovial sheaths are bound to phalanges by fibrous digital sheaths made up of alternating strong anular (A) and weaker cruciform (C) parts (pulleys).



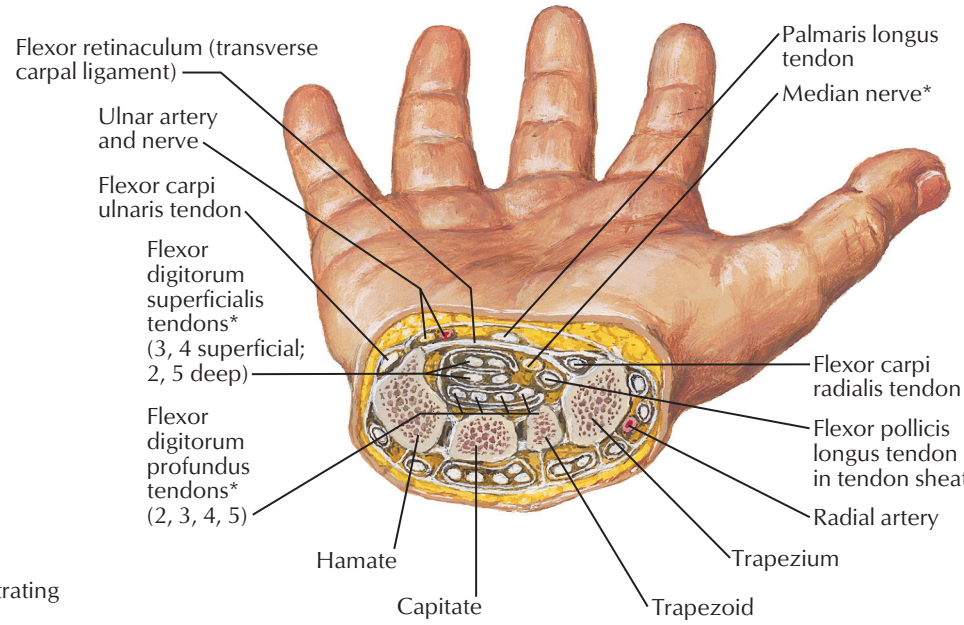
Flexor Tendons, Arteries, and Nerves at Wrist

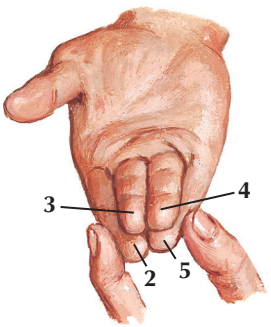
See also Plates 459, 460

Palmar view



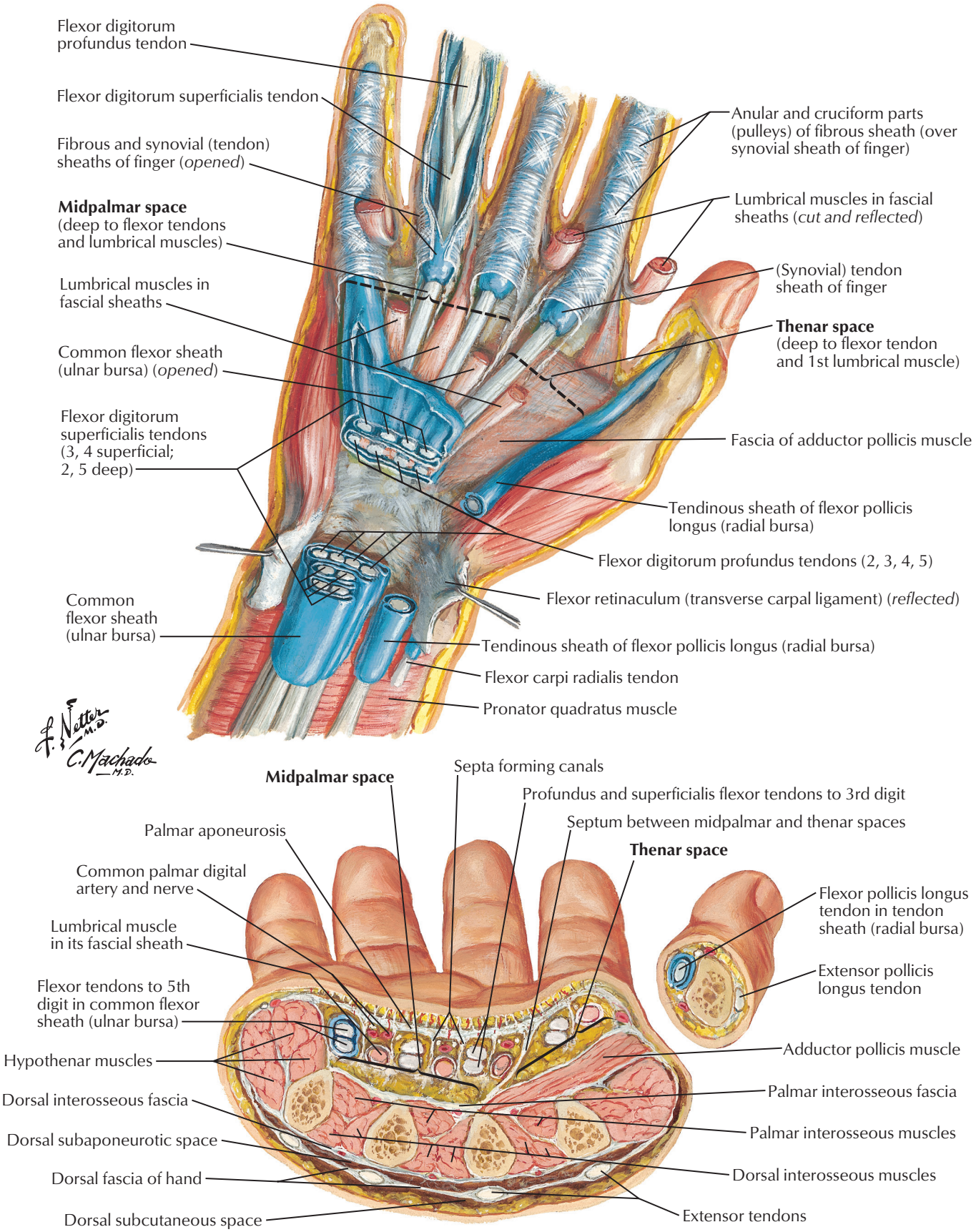
Cross section of wrist demonstrating carpal tunnel





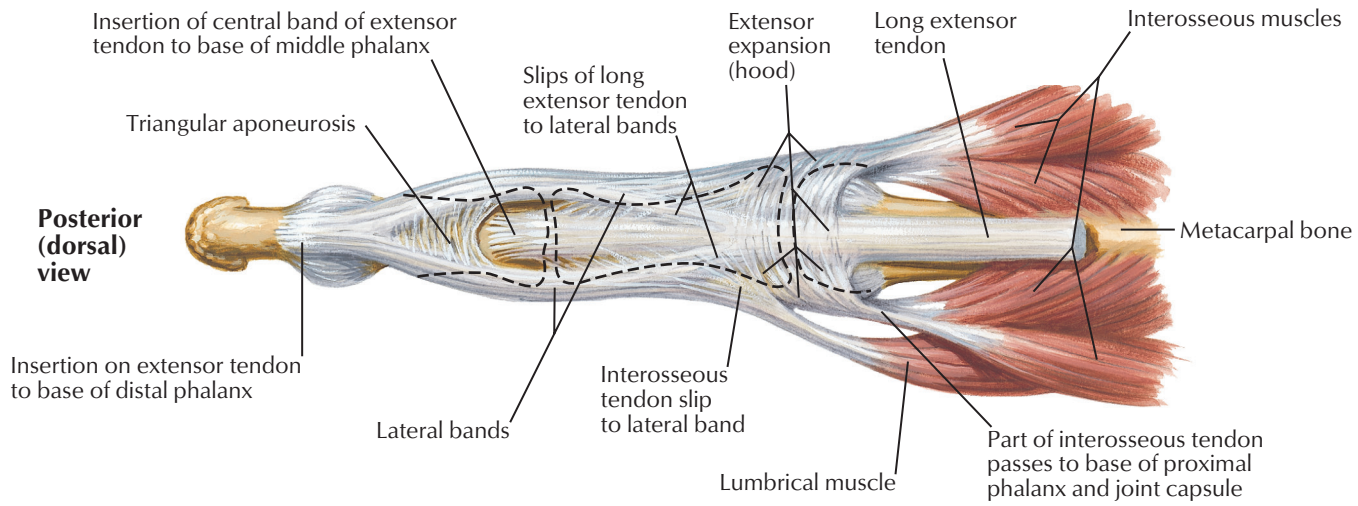
Simple method of demonstrating arrangement of flexor digitorum superficialis tendons within carpal tunnel

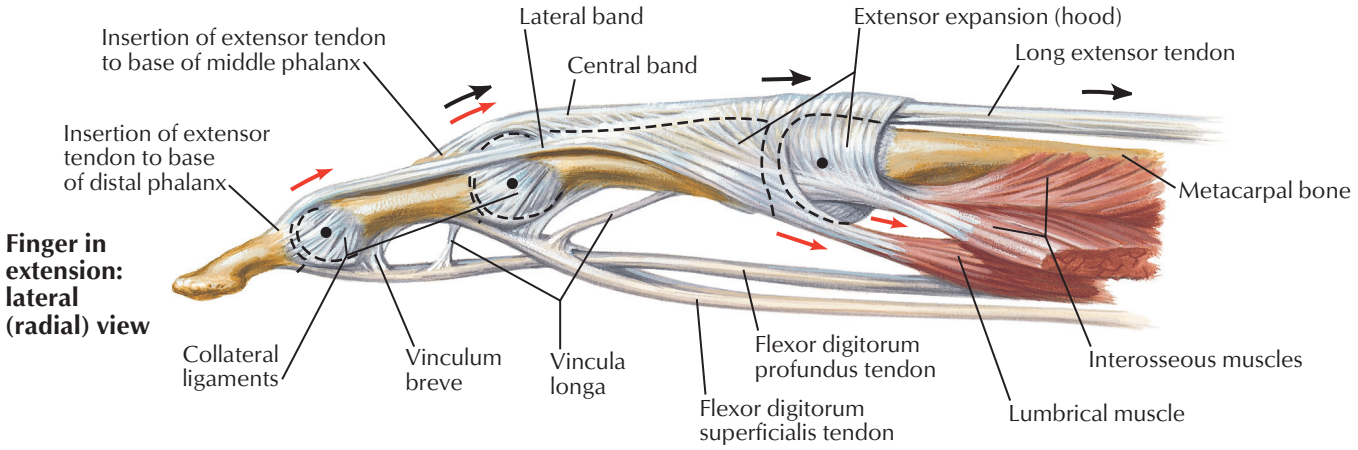
*Contents of carpal tunnel

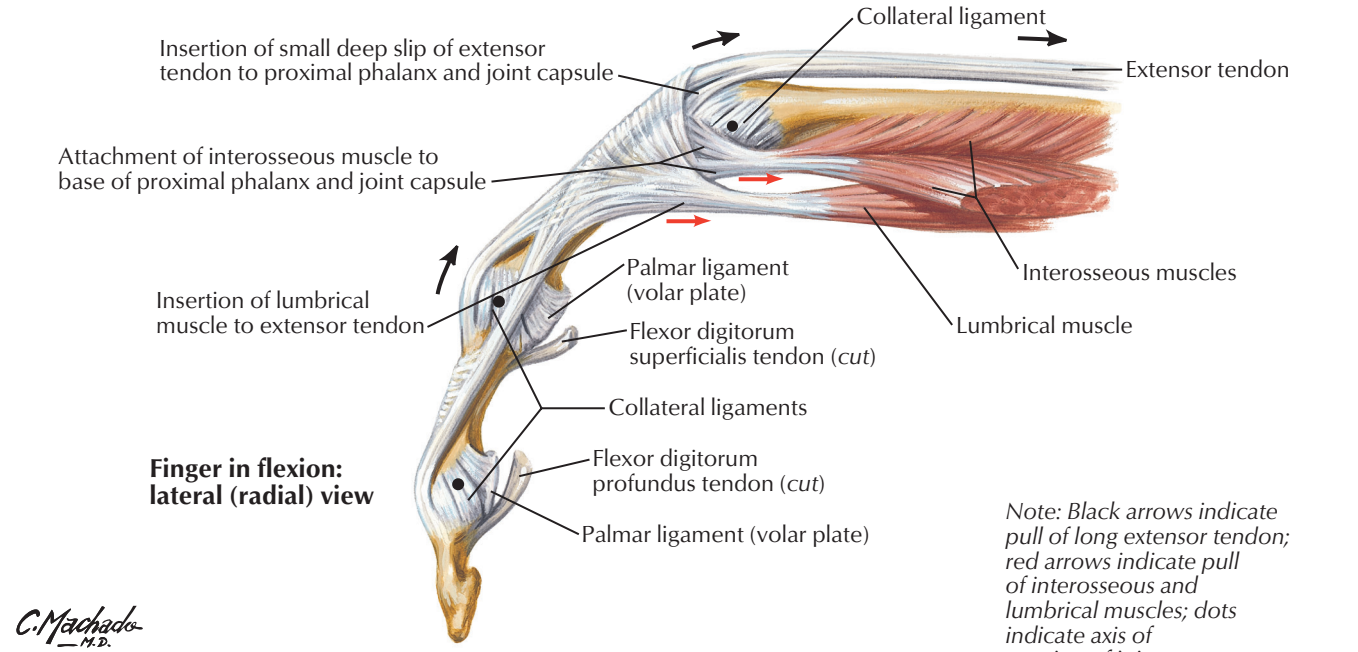

Flexor digitorum profundus tendon
Flexor digitorum superficialis tendon
Fibrous and synovial (tendon) sheaths of finger (*opened*)
Midpalmar space (deep to flexor tendons and lumbrical muscles)
Lumbrical muscles in fascial sheaths
Common flexor sheath (ulnar bursa) (*opened*)
Flexor digitorum superficialis tendons (3, 4 superficial; 2, 5 deep)
Common flexor sheath (ulnar bursa)
Anular and cruciform parts (pulleys) of fibrous sheath (over synovial sheath of finger)
Lumbrical muscles in fascial sheaths (*cut and reflected*)
(Synovial) tendon sheath of finger
Thenar space (deep to flexor tendon and 1st lumbrical muscle)
Fascia of adductor pollicis muscle
Tendinous sheath of flexor pollicis longus (radial bursa)
Flexor digitorum profundus tendons (2, 3, 4, 5)
Flexor retinaculum (transverse carpal ligament) (*reflected*)
Tendinous sheath of flexor pollicis longus (radial bursa)
Flexor carpi radialis tendon
Pronator quadratus muscle
F. Netter M.D.
C. Machado M.D.
Midpalmar space
Septa forming canals
Profundus and superficialis flexor tendons to 3rd digit
Septum between midpalmar and thenar spaces
Thenar space
Palmar aponeurosis
Common palmar digital artery and nerve
Lumbrical muscle in its fascial sheath
Flexor tendons to 5th digit in common flexor sheath (ulnar bursa)
Hypothenar muscles
Dorsal interosseous fascia
Dorsal subaponeurotic space
Dorsal fascia of hand
Dorsal subcutaneous space
Flexor pollicis longus tendon in tendon sheath (radial bursa)
Extensor pollicis longus tendon
Adductor pollicis muscle
Palmar interosseous fascia
Palmar interosseous muscles
Dorsal interosseous muscles
Extensor tendons

Flexor and Extensor Tendons in Fingers

See also Plate 445

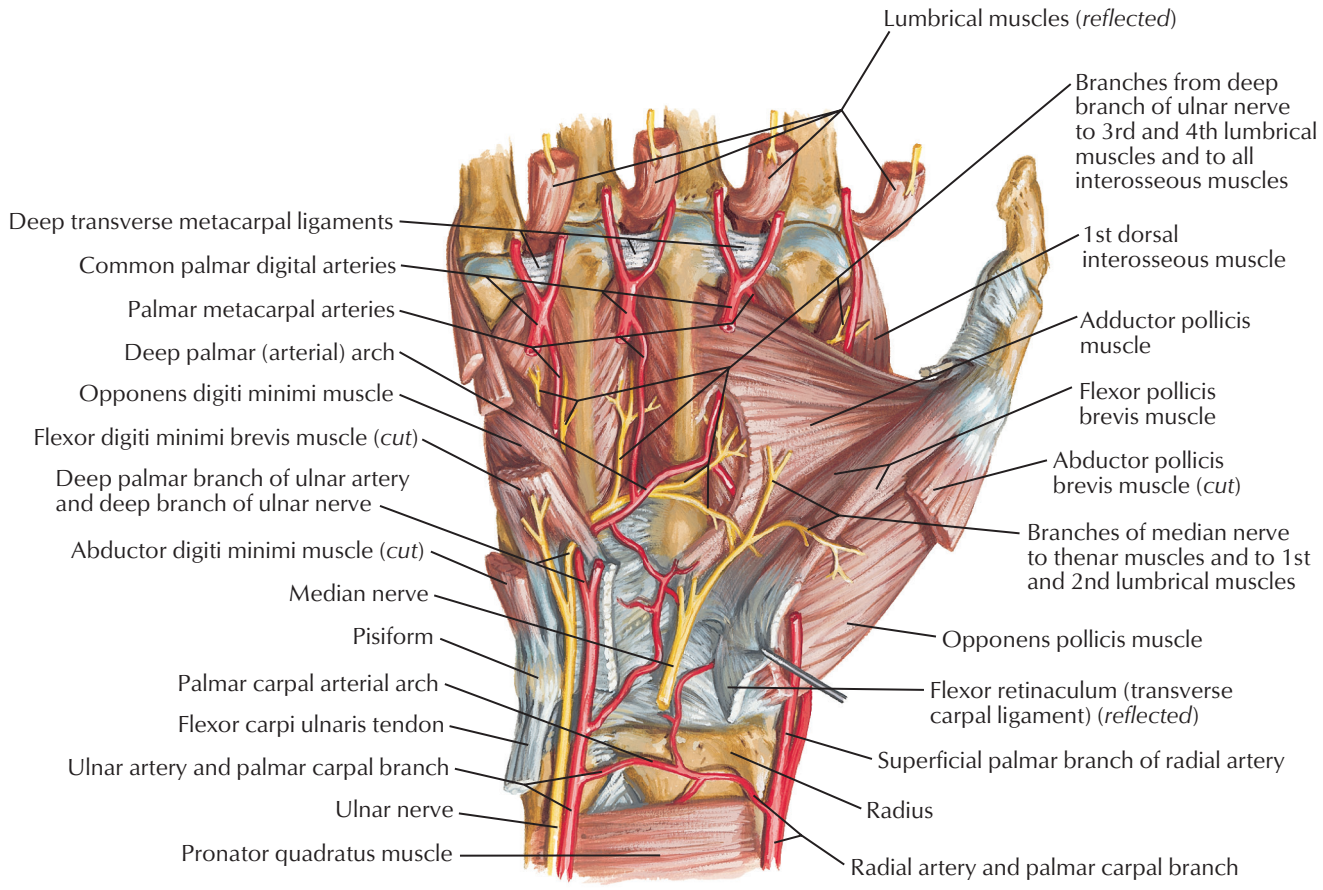




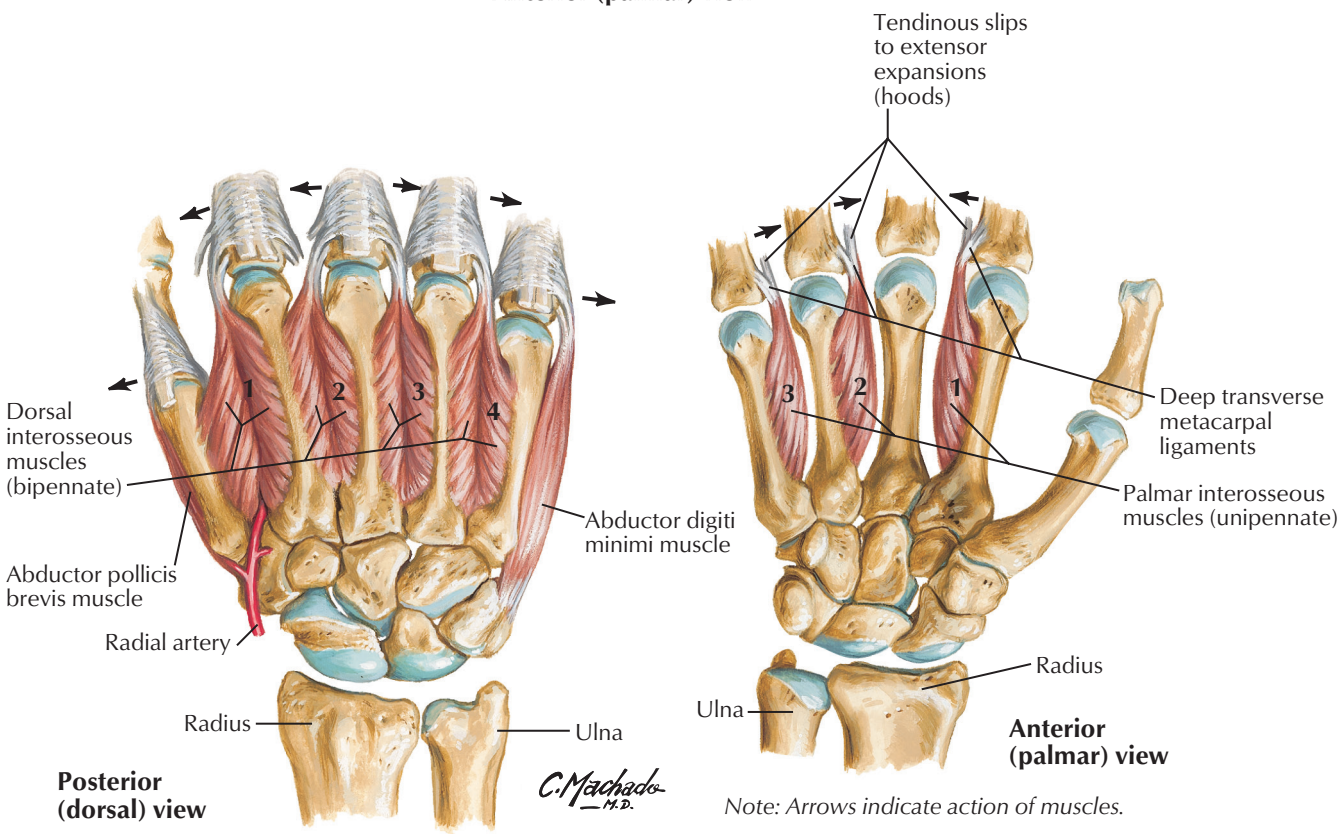


Note: Black arrows indicate pull of long extensor tendon; red arrows indicate pull of interosseous and lumbrical muscles; dots indicate axis of rotation of joints.

C. Machado M.D.



Anterior (palmar) view



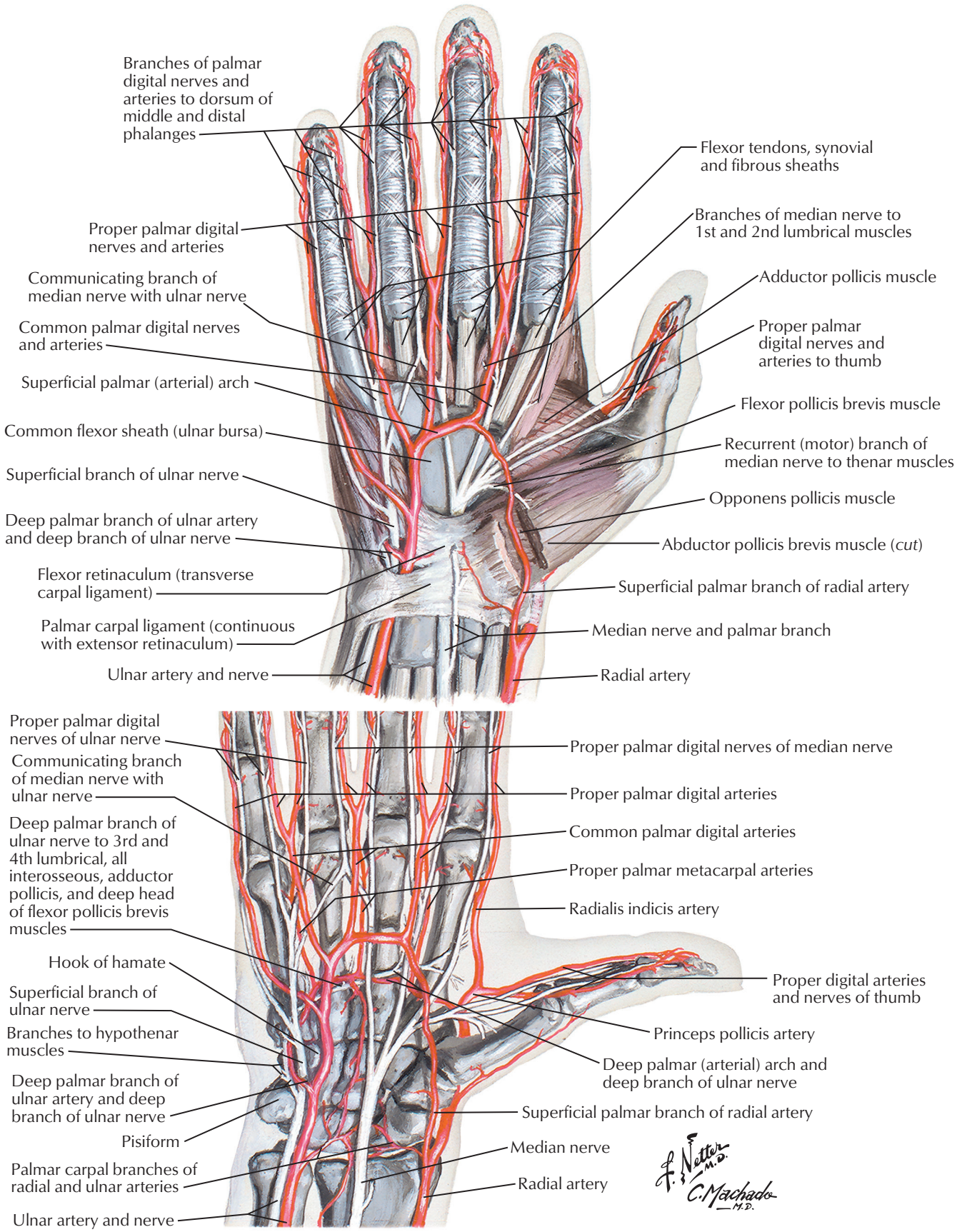
Posterior (dorsal) view

Anterior (palmar) view

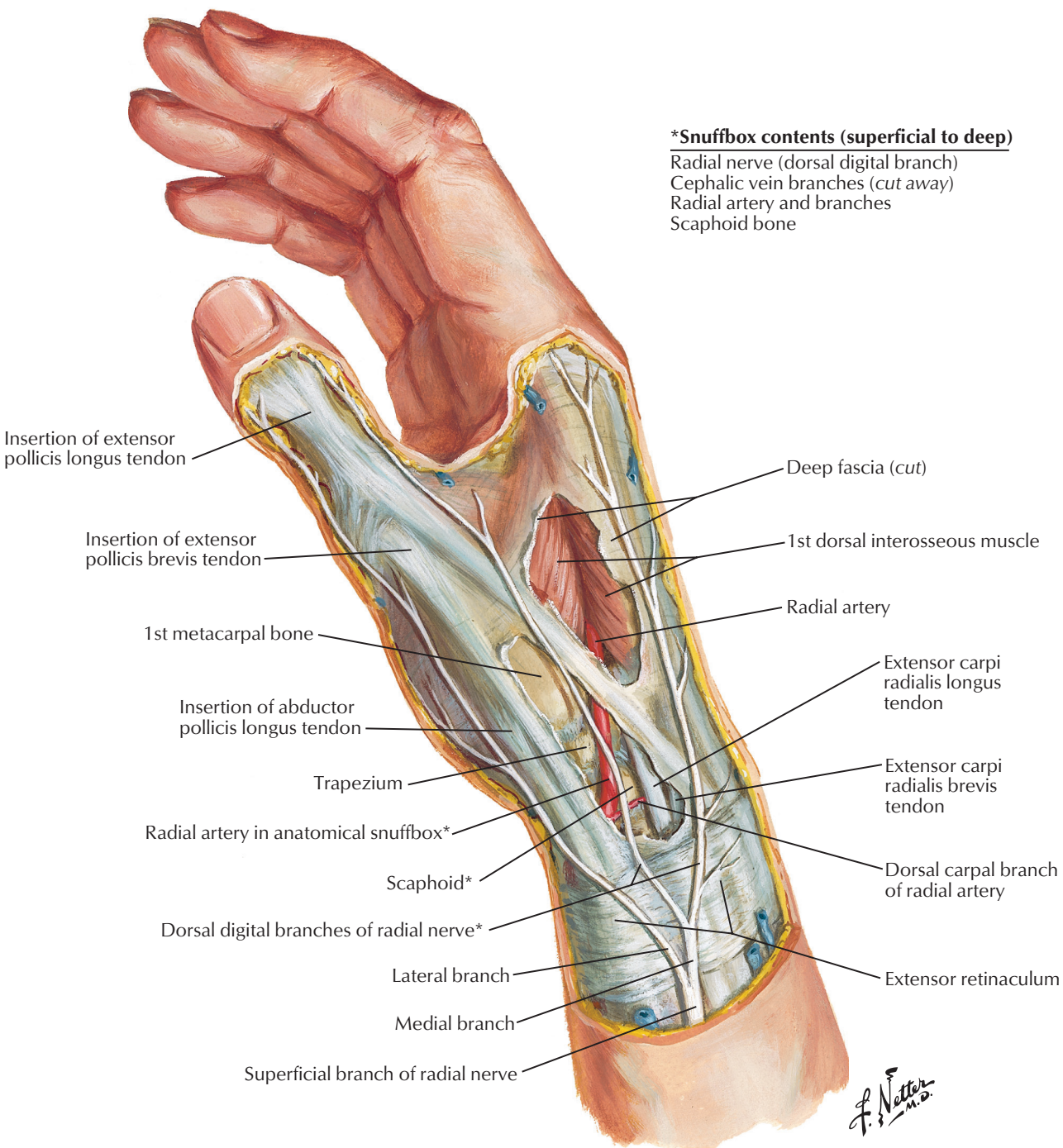
Note: Arrows indicate action of muscles.

Arteries and Nerves of Hand: Palmar Views

See also Plate 420

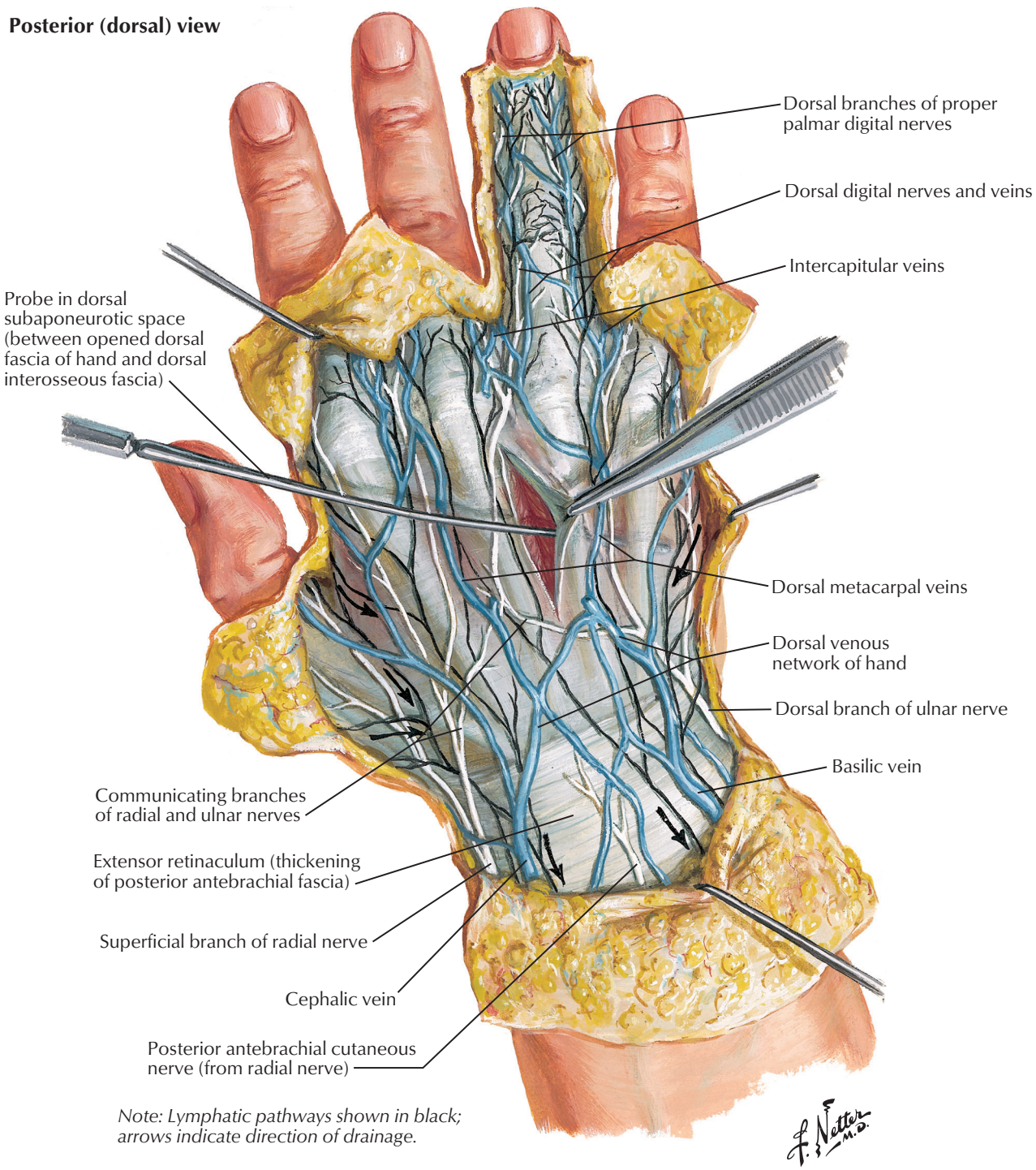


Lateral (radial) view

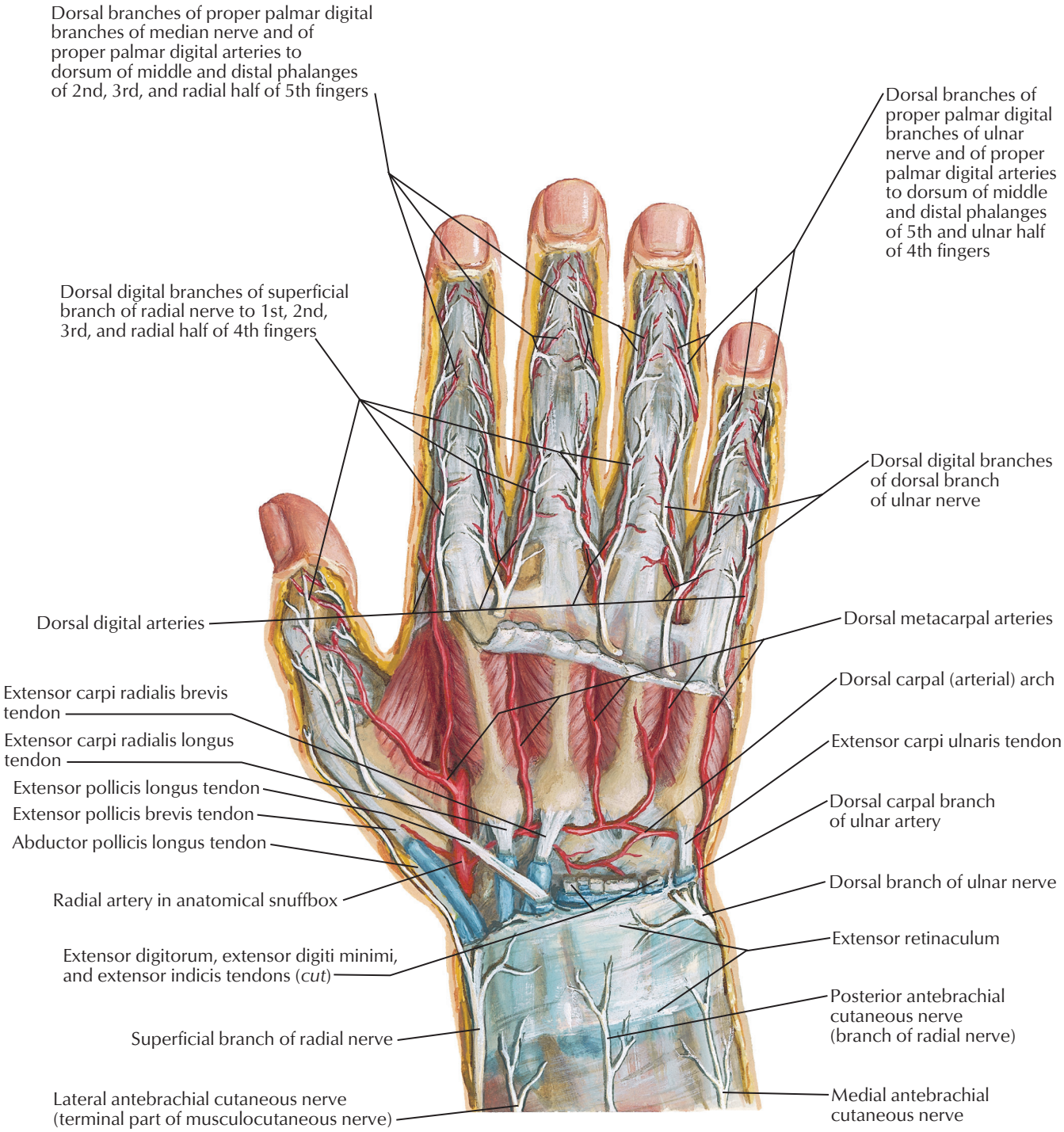


See also Plates 402, 403

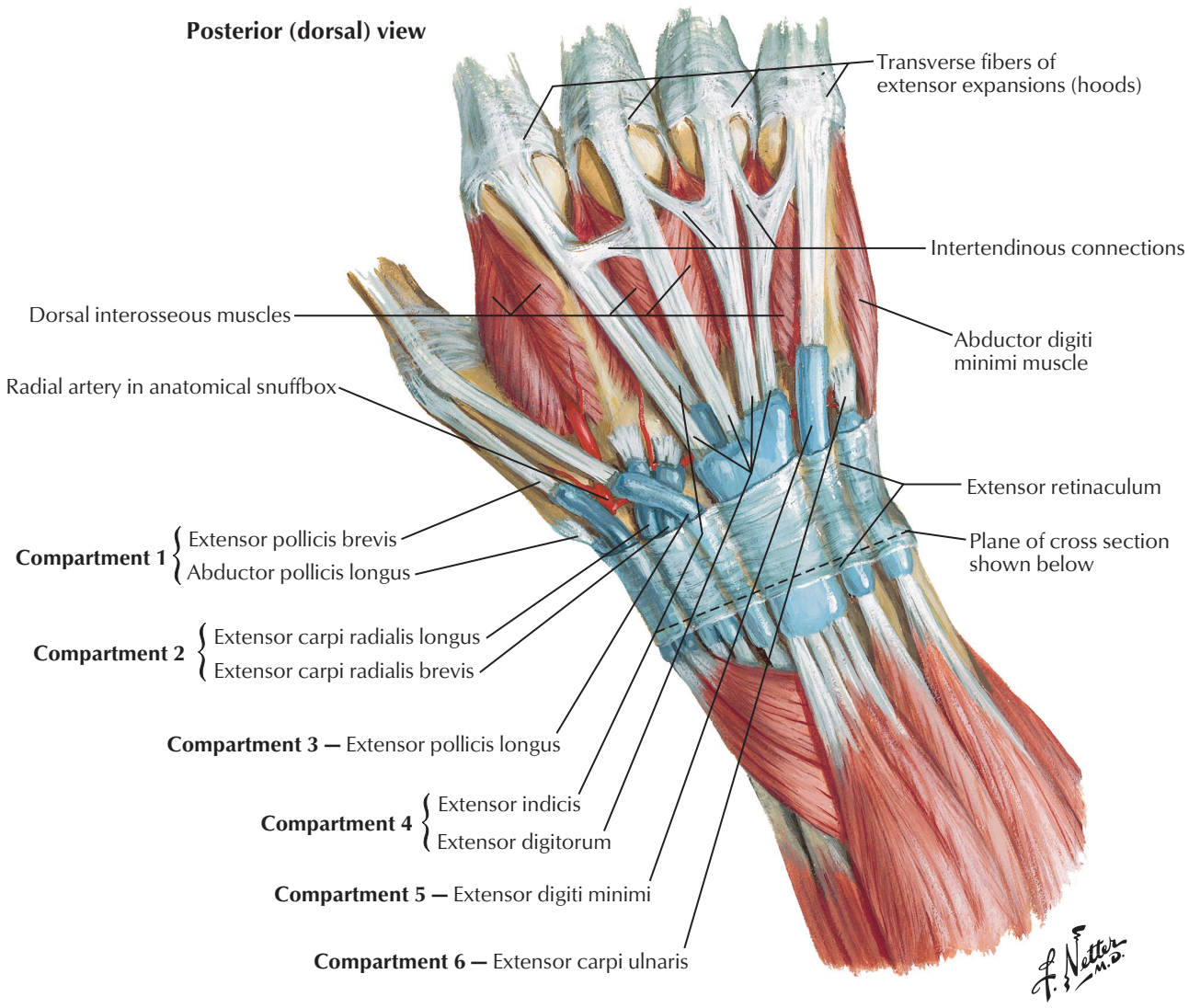
Posterior (dorsal) view



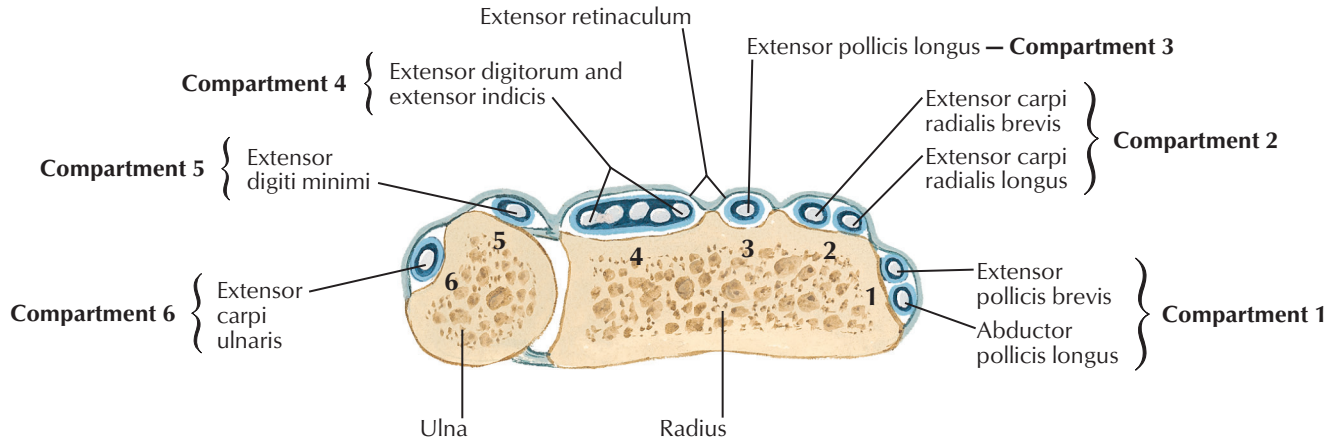
Note: Lymphatic pathways shown in black; arrows indicate direction of drainage.

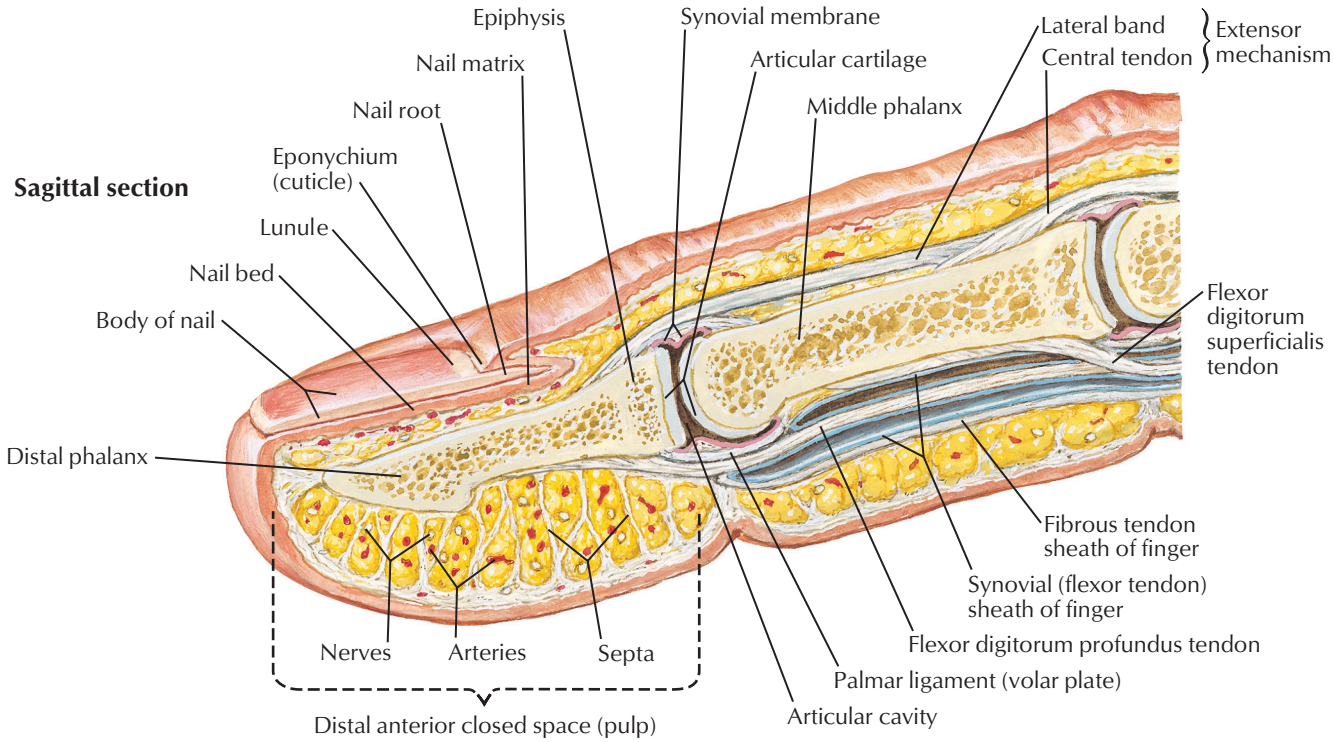


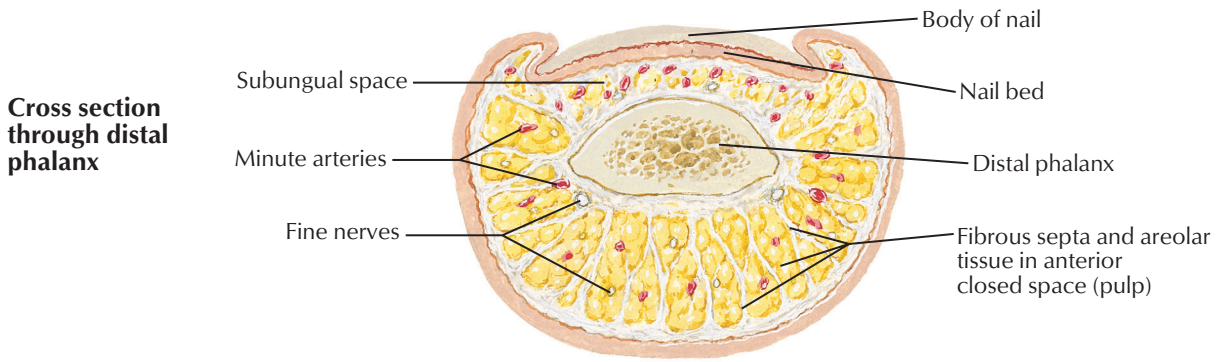
Posterior (dorsal) view

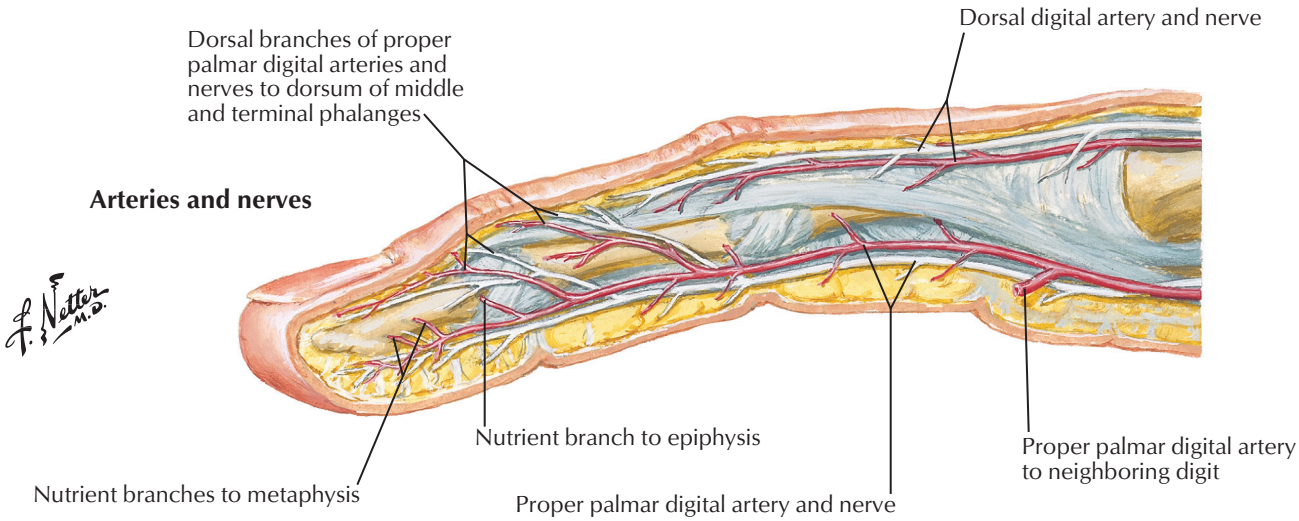


Cross section of most distal portion of forearm



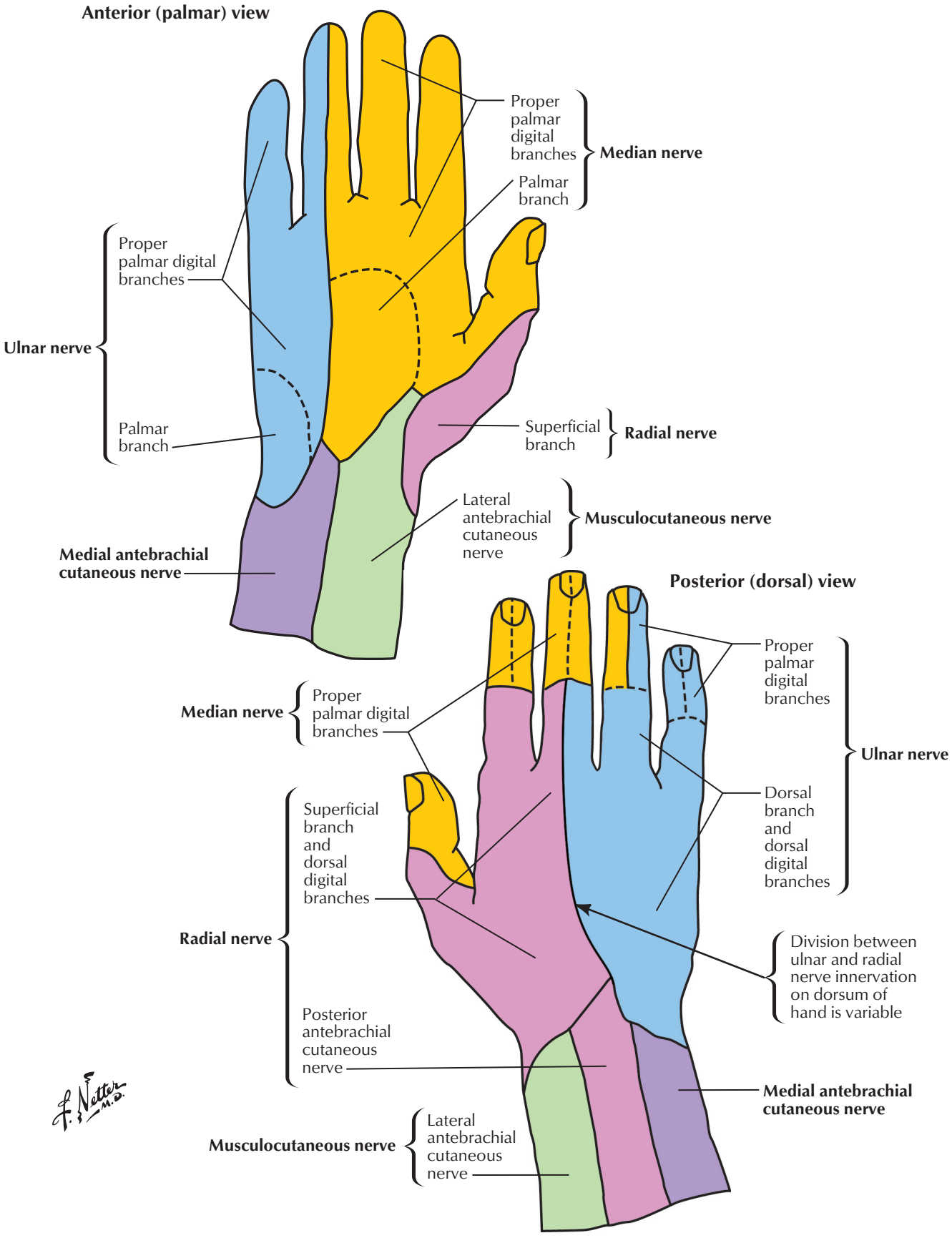

Sagittal section
Epiphysis
Synovial membrane
Nail matrix
Articular cartilage
Lateral band
Central tendon
Extensor mechanism
Nail root
Middle phalanx
Eponychium (cuticle)
Lunule
Nail bed
Body of nail
Flexor digitorum superficialis tendon
Distal phalanx
Fibrous tendon sheath of finger
Synovial (flexor tendon) sheath of finger
Flexor digitorum profundus tendon
Nerves
Arteries
Septa
Palmar ligament (volar plate)
Articular cavity
Distal anterior closed space (pulp)


Cross section through distal phalanx
Body of nail
Subungual space
Nail bed
Minute arteries
Distal phalanx
Fine nerves
Fibrous septa and areolar tissue in anterior closed space (pulp)

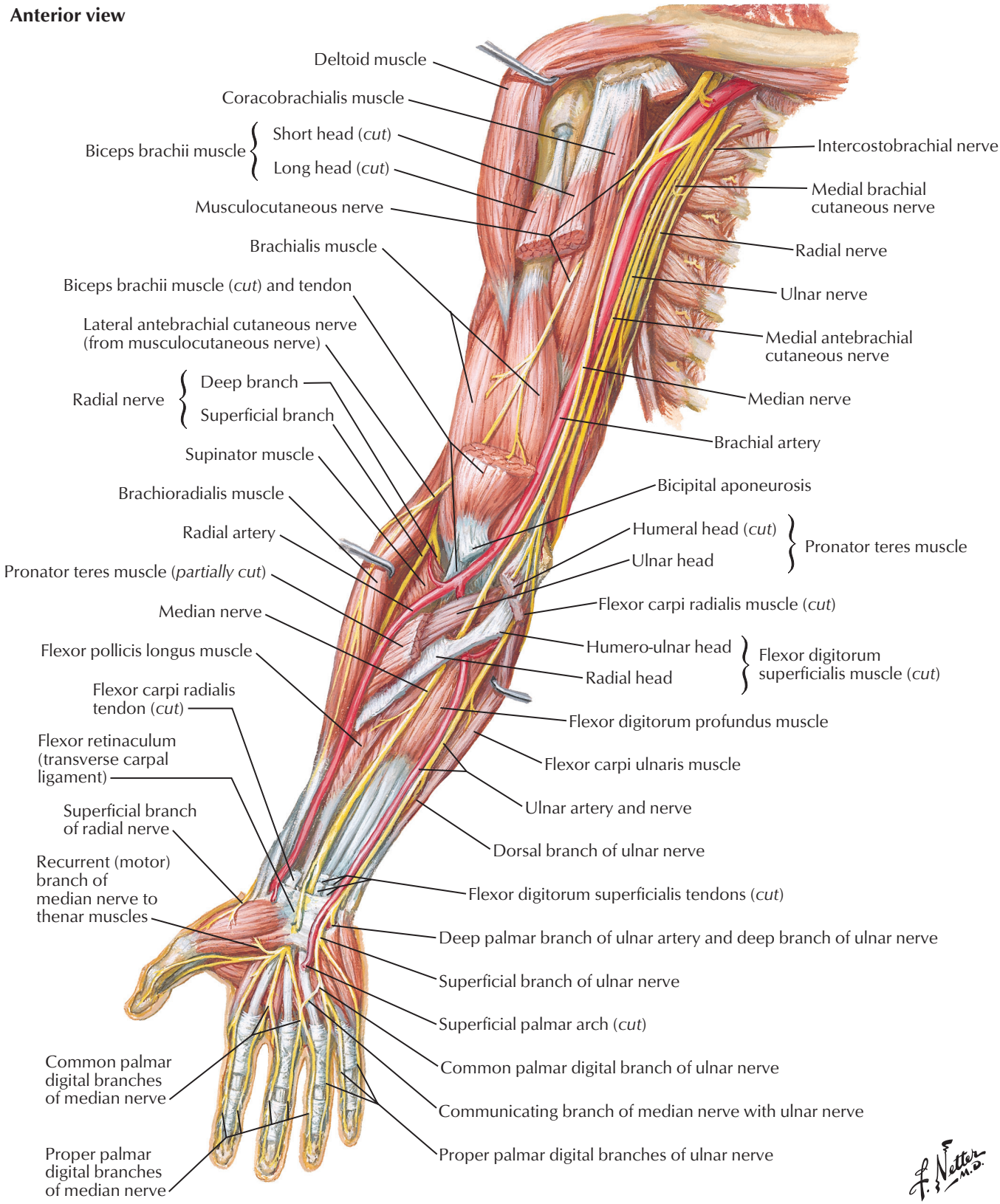

Arteries and nerves
Dorsal digital artery and nerve
Dorsal branches of proper palmar digital arteries and nerves to dorsum of middle and terminal phalanges
Nutrient branch to epiphysis
Proper palmar digital artery to neighboring digit
Nutrient branches to metaphysis
Proper palmar digital artery and nerve

Cutaneous Innervation of Wrist and Hand

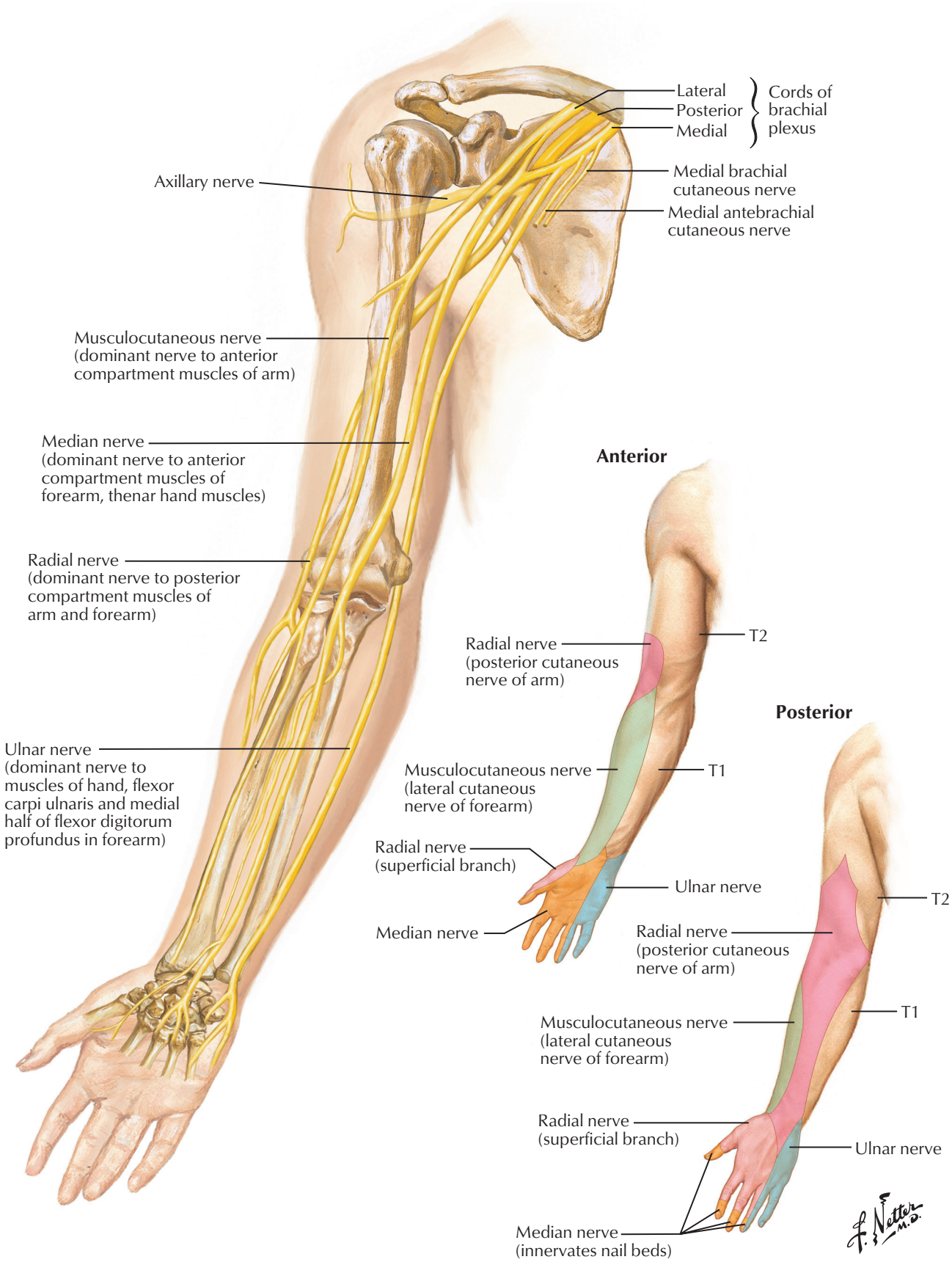
See also Plates 400, 449

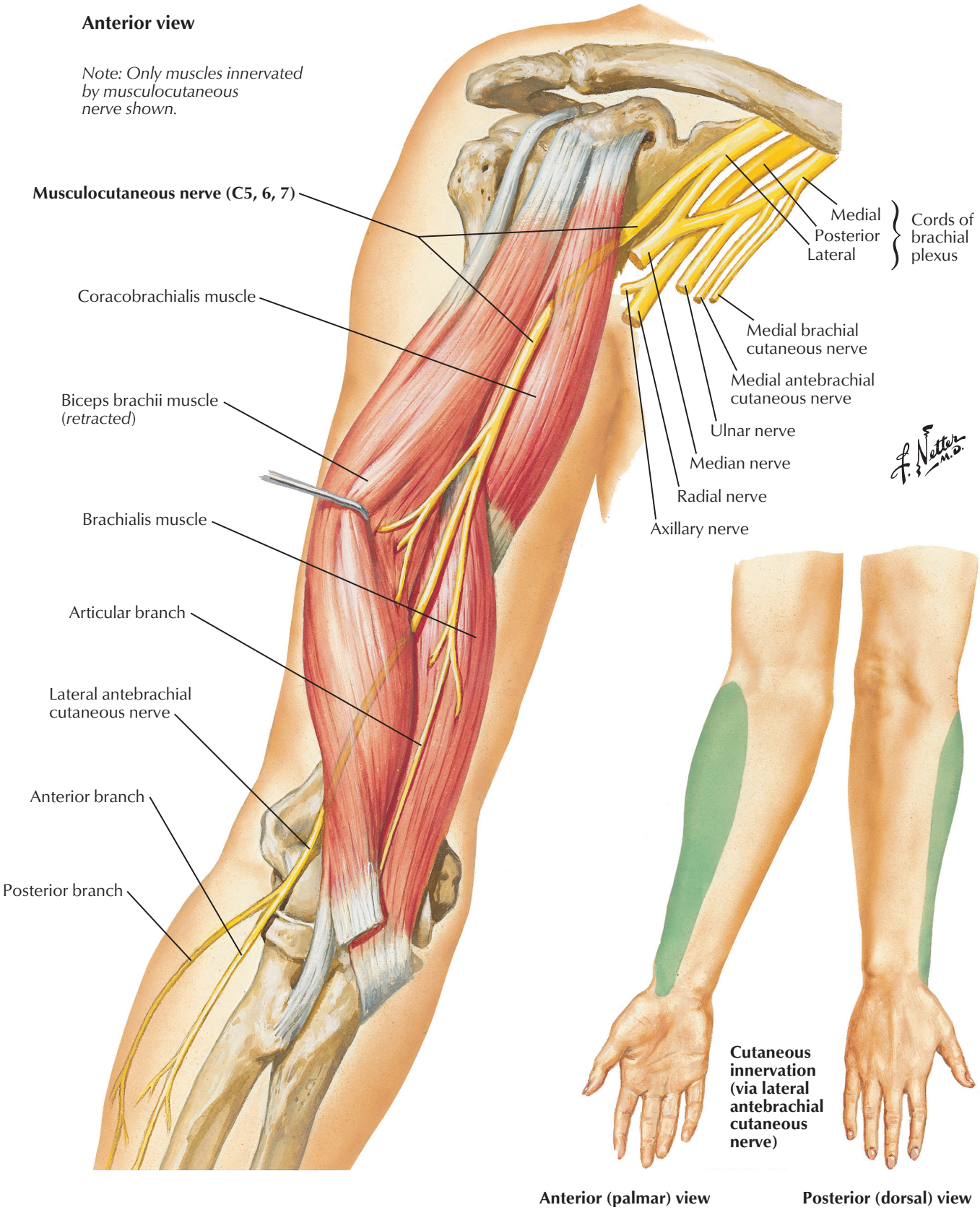


Anterior view



See also Plates 400, 410, 416



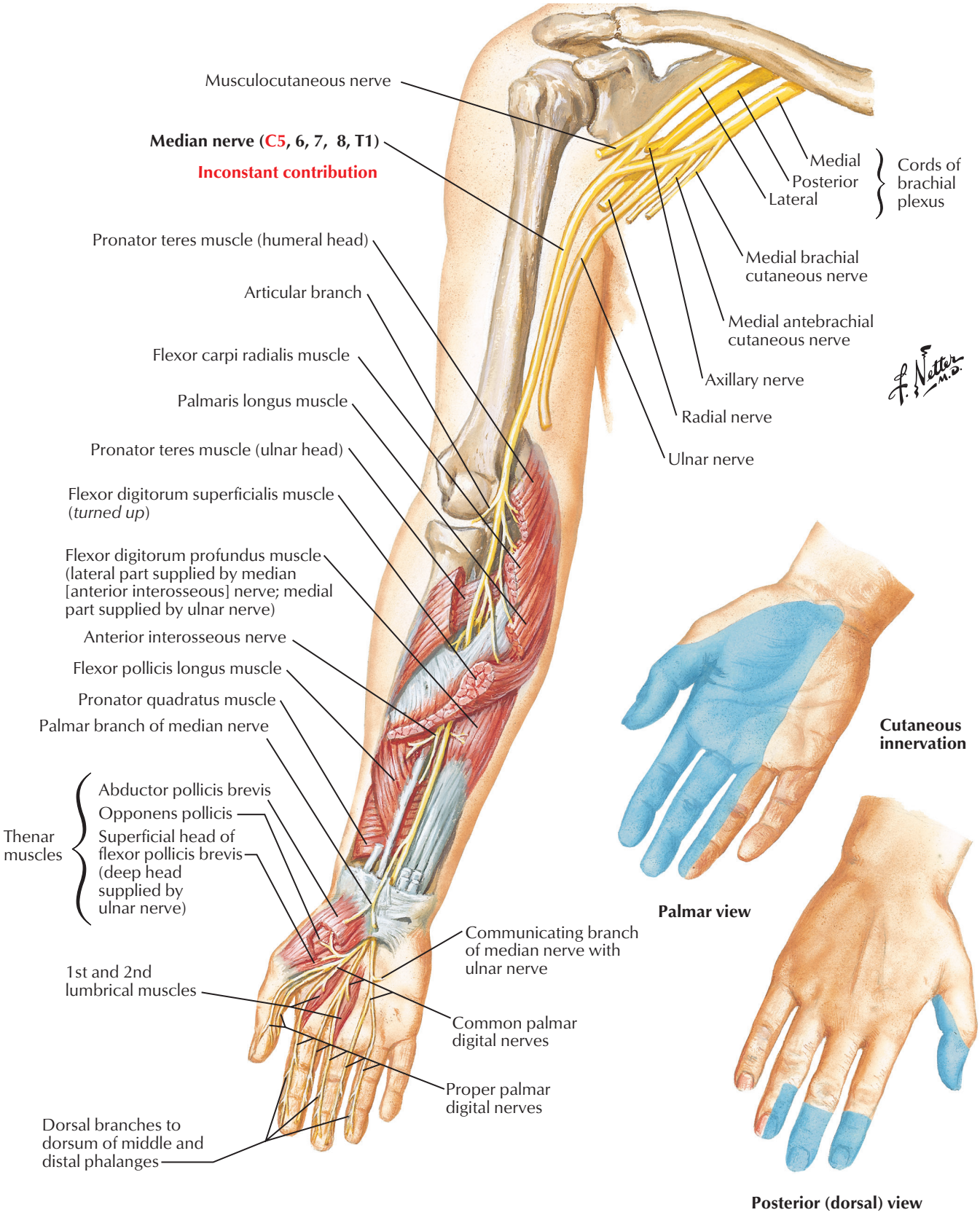

Anterior view
Note: Only muscles innervated by musculocutaneous nerve shown.
Musculocutaneous nerve (C5, 6, 7)
Coracobrachialis muscle
Biceps brachii muscle (retracted)
Brachialis muscle
Articular branch
Lateral antebrachial cutaneous nerve
Anterior branch
Posterior branch
Medial
Posterior
Lateral
Cords of brachial plexus
Medial brachial cutaneous nerve
Medial antebrachial cutaneous nerve
Ulnar nerve
Median nerve
Radial nerve
Axillary nerve
F. Netter M.D.
Cutaneous innervation (via lateral antebrachial cutaneous nerve)
Anterior (palmar) view
Posterior (dorsal) view

Median Nerve

See also **Plates 400, 432, 433**

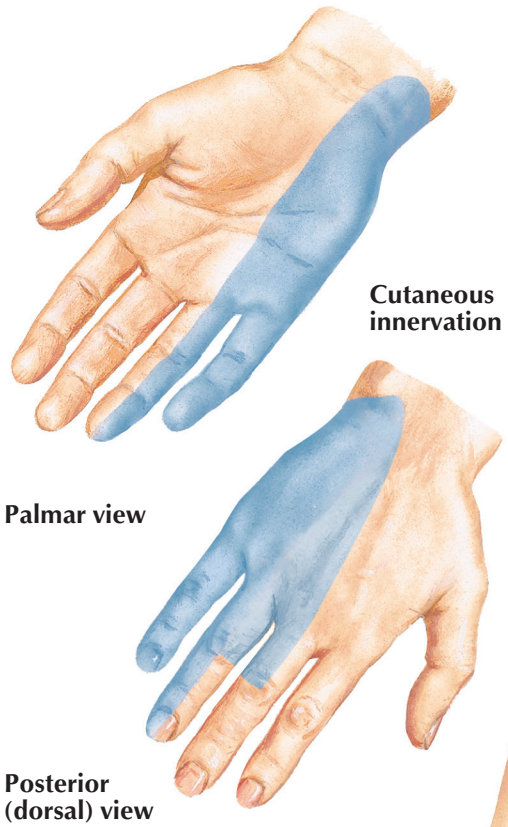
Anterior view

Note: Only muscles innervated by median nerve shown.



Anterior view

Note: Only muscles innervated by ulnar nerve shown.



Cutaneous innervation

Palmar view

Posterior (dorsal) view

Ulnar nerve (C7, 8, T1)
(no branches above elbow)

Inconstant contribution

Medial epicondyle

Articular branch (behind condyle)

Flexor digitorum profundus muscle (medial part only; lateral part supplied by anterior interosseous branch of median nerve)

Flexor carpi ulnaris muscle (*retracted*)

Dorsal branch of ulnar nerve

Palmar branch

Palmar carpal ligament

Superficial branch

Deep branch

Flexor pollicis brevis muscle (deep head only; superficial head and other thenar muscles supplied by median nerve)

Adductor pollicis muscle

Palmaris brevis

Abductor digiti minimi

Flexor digiti minimi brevis

Opponens digiti minimi

Hypothenar muscles

Common palmar digital nerve

Communicating branch of median nerve with ulnar nerve

1st dorsal interosseous muscle

Palmar interosseous muscles

3rd and 4th lumbrical muscles (*turned down*)

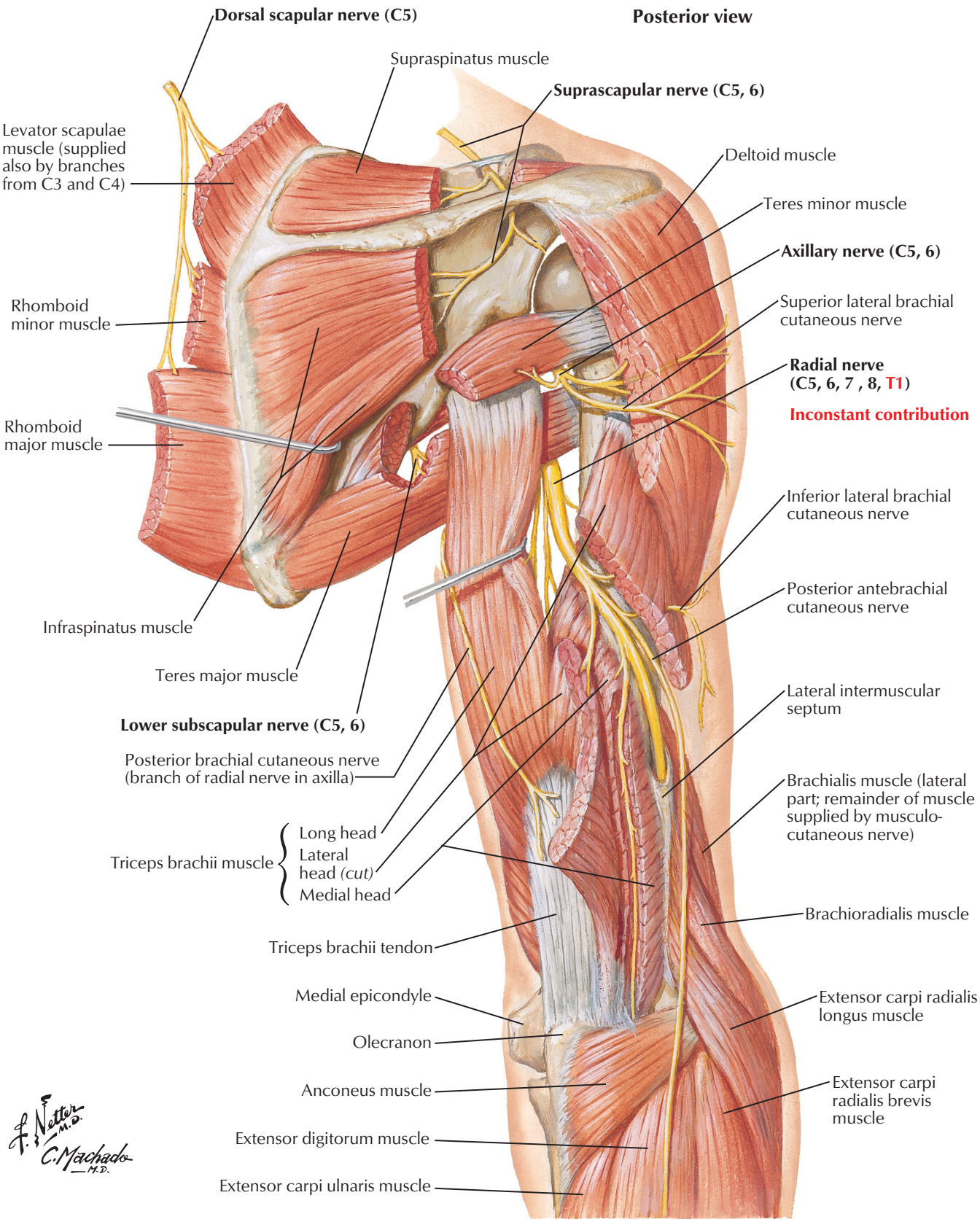
Palmar digital nerves (dorsal digital nerves are from dorsal branch)

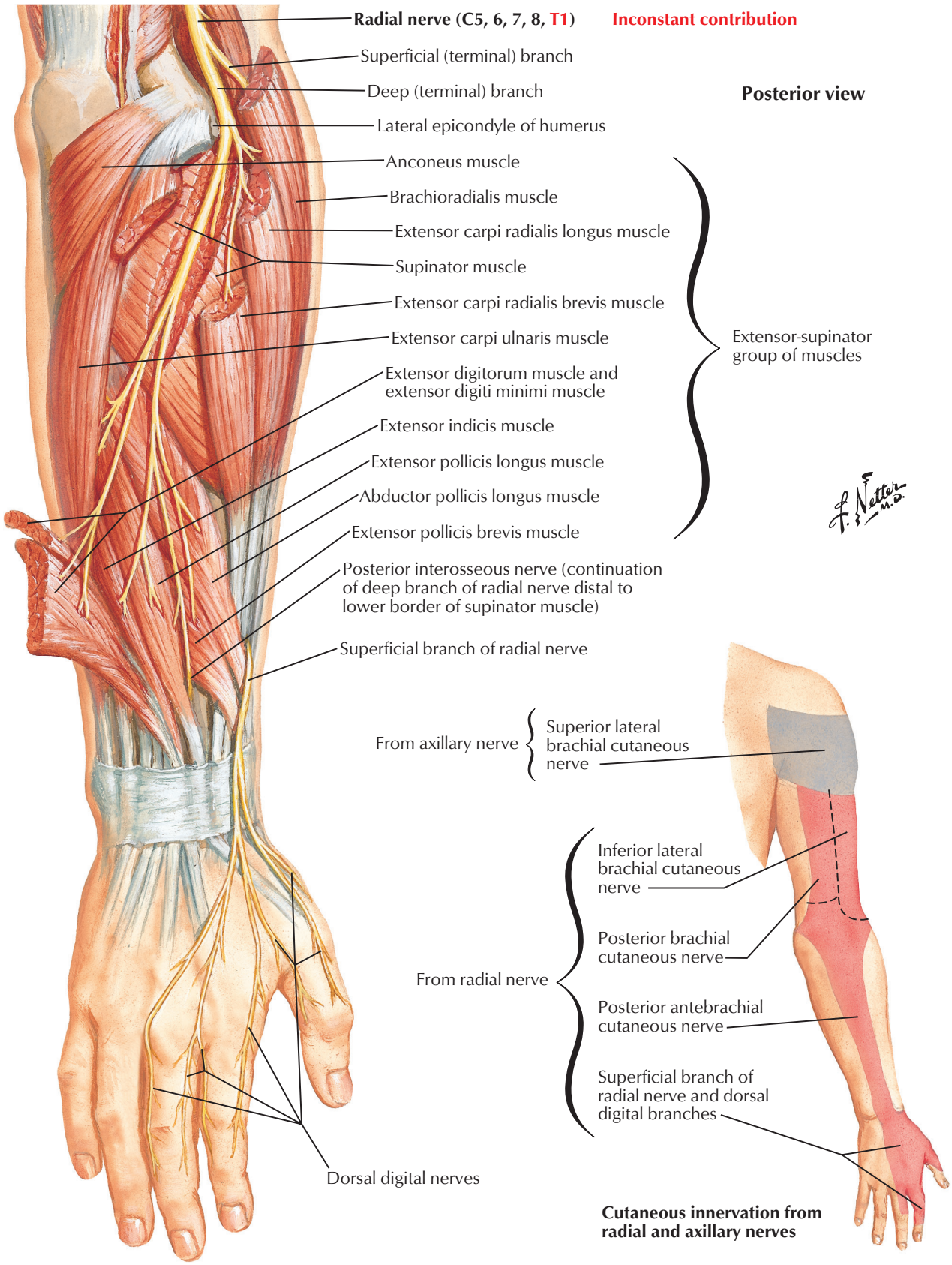
Dorsal branches to dorsum of middle and distal phalanges

F. Netter M.D.

Radial Nerve in Arm and Nerves of Posterior Shoulder

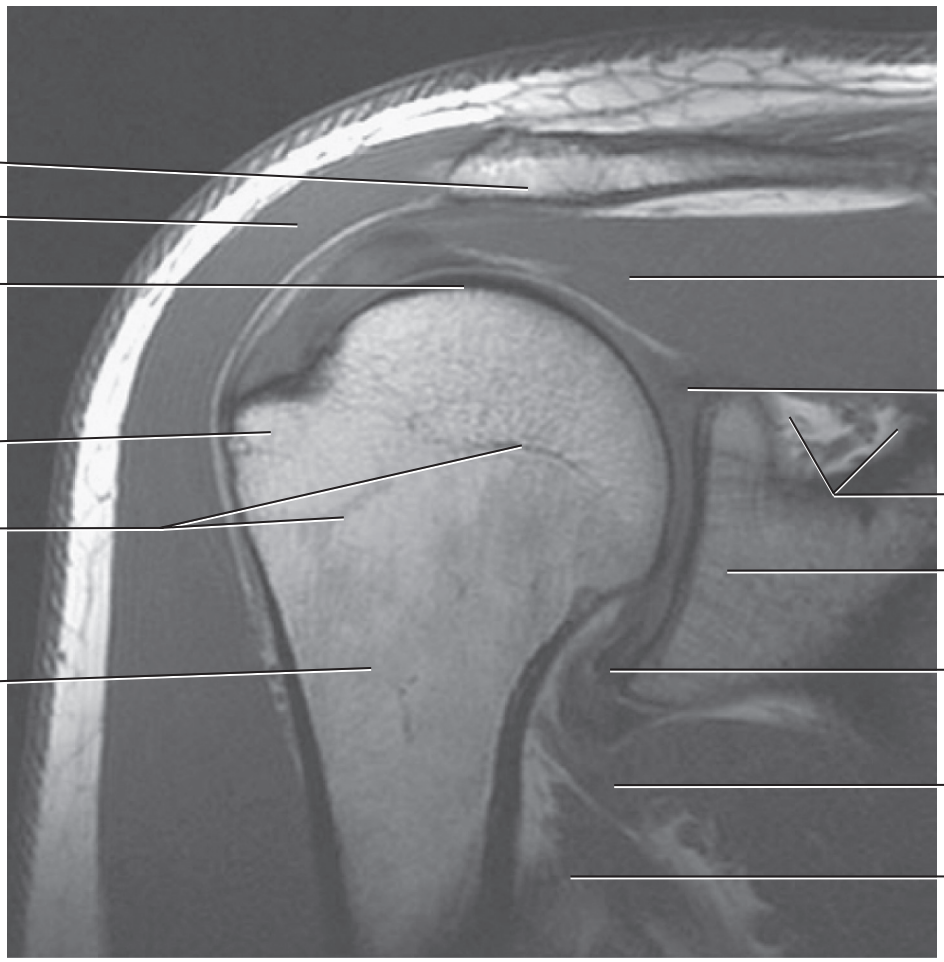
See also Plates 413, 418



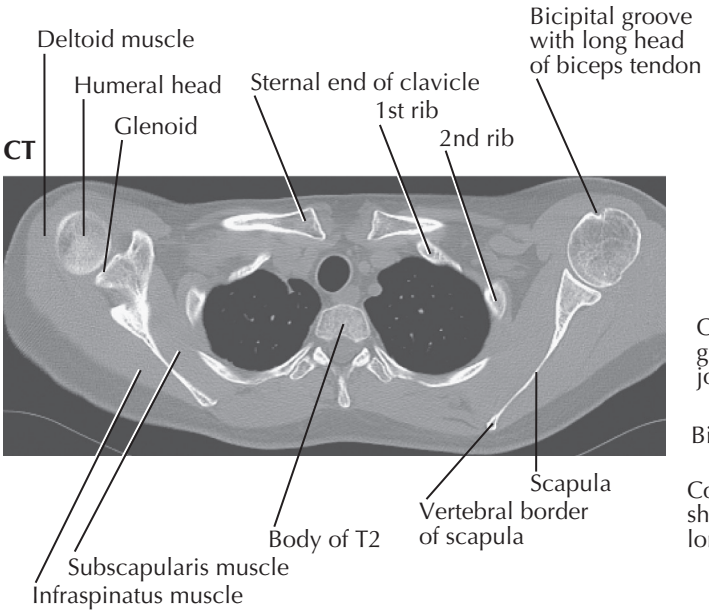

Radial nerve (C5, 6, 7, 8, T1)
Inconstant contribution
Superficial (terminal) branch
Deep (terminal) branch
Posterior view
Lateral epicondyle of humerus
Anconeus muscle
Brachioradialis muscle
Extensor carpi radialis longus muscle
Supinator muscle
Extensor carpi radialis brevis muscle
Extensor carpi ulnaris muscle
Extensor digitorum muscle and extensor digiti minimi muscle
Extensor indicis muscle
Extensor pollicis longus muscle
Abductor pollicis longus muscle
Extensor pollicis brevis muscle
Extensor-supinator group of muscles
Posterior interosseous nerve (continuation of deep branch of radial nerve distal to lower border of supinator muscle)
Superficial branch of radial nerve
From axillary nerve
Superior lateral brachial cutaneous nerve
Inferior lateral brachial cutaneous nerve
From radial nerve
Posterior brachial cutaneous nerve
Posterior antebrachial cutaneous nerve
Superficial branch of radial nerve and dorsal digital branches
Dorsal digital nerves
Cutaneous innervation from radial and axillary nerves

See also Plate 408

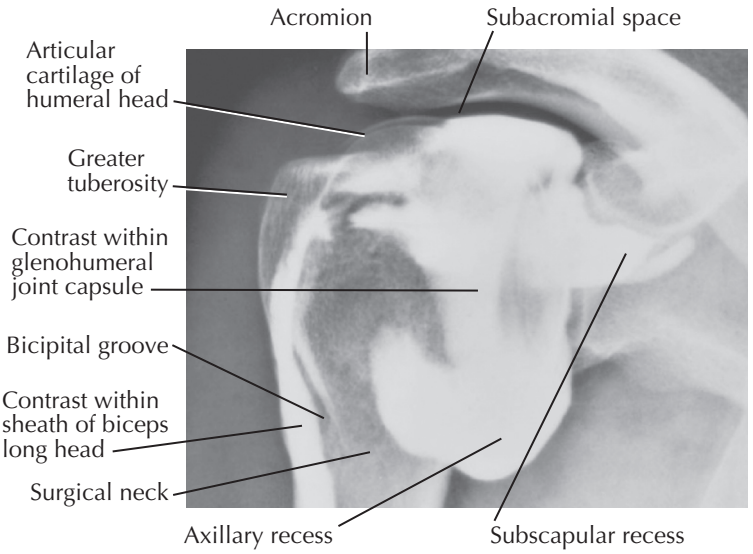
MRI



CT



Arthrogram: glenohumeral joint



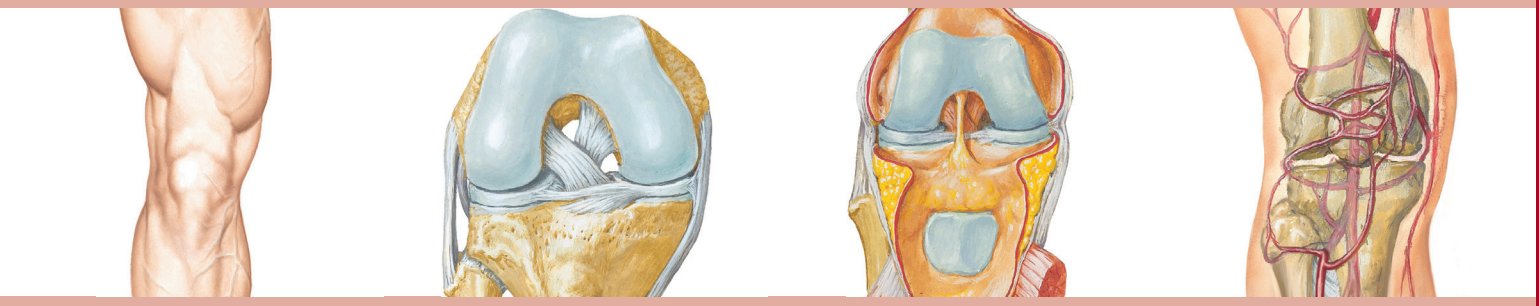
MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Abductor digiti minimi	Pisiform bone and tendon of flexor carpi ulnaris	Medial side of base of proximal phalanx of little finger (5th digit)	Ulnar nerve (deep branch)	Abducts little finger	Deep palmar branch of ulnar artery	Hand
Abductor pollicis brevis	Flexor retinaculum, tubercles of scaphoid and trapezium	Lateral side of base of proximal phalanx of thumb	Median nerve (recurrent branch)	Abducts thumb	Superficial palmar branch of radial artery	Hand
Abductor pollicis longus	Posterior surface of ulna, radius, and interosseous membrane	Base of 1st metacarpal	Radial nerve (posterior interosseous)	Abducts and extends thumb at carpometacarpal joint	Posterior interosseous artery	Posterior forearm
Adductor pollicis	*Oblique head*: bases of 2nd and 3rd metacarpals and capitate and adjacent bones *Transverse head:* anterior surface of 3rd metacarpal	Medial side of base of proximal phalanx of thumb	Ulnar nerve (deep branch)	Adducts thumb	Deep palmar arch	Hand
Anconeus	Posterior surface of lateral epicondyle of humerus	Lateral surface of olecranon and posterior proximal ulna	Radial nerve (C5–T1)	Assists triceps in extending elbow, abducts ulna in pronation	Deep brachial artery	Arm
Biceps brachii	*Long head:* supraglenoid tubercle of scapula *Short head:* tip of coracoid process of scapula	Radial tuberosity, fascia of forearm via bicipital aponeurosis	Musculocutaneous nerve (C5,C6)	Flexes and supinates forearm at elbow	Muscular branches of brachial artery	Arm
Brachialis	Distal half of anterior surface of humerus	Coronoid process and tuberosity of ulna	Musculocutaneous nerve and radial nerve (C7)	Flexes forearm at elbow	Radial recurrent artery, muscular branches of brachial artery	Arm
Brachioradialis	Proximal 2/3 of lateral supracondylar ridge of humerus	Lateral side of distal end of radius	Radial nerve	Weak flexion of forearm when forearm is midpronated	Radial recurrent artery	Posterior forearm
Coracobrachialis	Tip of coracoid process of scapula	Middle third of medial surface of humerus	Musculocutaneous nerve	Flexes and adducts arm at shoulder	Muscular branches of brachial artery	Arm
Deltoid	Lateral third of anterior clavicle, lateral acromion, inferior edge of spine of scapula	Deltoid tuberosity of humerus	Axillary nerve	*Clavicular part*: flexes and medially rotates arm *Acromial part:* abducts arm beyond initial 15 degrees done by supraspinatus *Spinal part:* extends and laterally rotates arm	Posterior circumflex humeral artery, deltoid branch of thoraco-acromial artery	Shoulder
Dorsal interosseous muscles	Adjacent sides of two metacarpal bones	Base of proximal phalanges, extensor expansion of digits 2–4	Ulnar nerve (deep branch)	Abduct digits from axial line of hand (3rd digit); flex digits at metacarpophalangeal joint and extend interphalangeal joints	Deep palmar arch	Hand
Extensor carpi radialis brevis	Lateral epicondyle of humerus	Dorsal base of 3rd metacarpal and slip to 2nd metacarpal	Radial nerve (deep branch)	Extends and abducts hand at wrist	Radial artery, radial recurrent artery	Posterior forearm
Extensor carpi radialis longus	Distal third of lateral supracondylar ridge of humerus	Dorsal base of 2nd metacarpal and slip to 3rd metacarpal	Radial nerve	Extends and abducts hand at wrist	Radial artery, radial recurrent artery	Posterior forearm

Variations in spinal nerve contributions to the innervation of muscles, their arterial supply, their attachments, and their actions are common themes in human anatomy. Therefore, expect differences between texts and realize that anatomical variation is normal.

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Extensor carpi ulnaris	Lateral epicondyle of humerus and posterior border of ulna	Dorsal base of 5th metacarpal	Radial nerve (posterior interosseous)	Extends and adducts hand at wrist	Posterior interosseous artery	Posterior forearm
Extensor digiti minimi	Lateral epicondyle of humerus	Extensor expansion of 5th digit	Radial nerve (posterior interosseous)	Extends 5th digit	Posterior interosseous artery	Posterior forearm
Extensor digitorum	Lateral epicondyle of humerus	Extensor expansions of medial four digits	Radial nerve (posterior interosseous)	Extends medial four digits, assists in wrist extension	Posterior interosseous artery	Posterior forearm
Extensor indicis	Posterior surface of ulna and interosseous membrane	Extensor expansion of 2nd digit	Radial nerve (posterior interosseous)	Extends 2nd digit and helps extend hand at wrist	Posterior interosseous artery	Posterior forearm
Extensor pollicis brevis	Posterior surface of radius and interosseous membrane	Dorsal base of proximal phalanx of thumb	Radial nerve (posterior interosseous)	Extends proximal phalanx of thumb at carpometacarpal joint	Posterior interosseous artery	Posterior forearm
Extensor pollicis longus	Posterior surface of middle third of ulna, interosseous membrane	Dorsal base of distal phalanx of thumb	Radial nerve (posterior interosseous)	Extends distal phalanx of thumb at interphalangeal and metacarpophalangeal joints	Posterior interosseous artery	Posterior forearm
Flexor carpi radialis	Medial epicondyle of humerus	Base of 2nd metacarpal	Median nerve	Flexes and abducts hand at wrist	Radial artery	Anterior forearm
Flexor carpi ulnaris	*Humeral head:* medial epicondyle of humerus *Ulnar head:* olecranon and posterior border of ulna	Pisiform bone, hook of hamate, base of 5th metacarpal	Ulnar nerve	Flexes and adducts hand at wrist	Posterior ulnar recurrent artery	Anterior forearm
Flexor digiti minimi brevis	Flexor retinaculum and hook of hamate bone	Medial side of base of proximal phalanx of little finger	Ulnar nerve (deep branch)	Flexes proximal phalanx of little finger	Deep palmar branch of ulnar artery	Hand
Flexor digitorum profundus	Medial and anterior surface of proximal 3/4 of ulna and interosseous membrane	Palmar base of distal phalanges of medial four digits	*Medial part:* ulnar nerve *Lateral part:* median nerve	Flexes distal phalanges of medial four digits, assists with flexion of hand at wrist	Anterior interosseous artery, muscular branches of ulnar artery	Anterior forearm
Flexor digitorum superficialis	*Humero-ulnar head:* medial epicondyle of humerus and coronoid process of ulna *Radial head:* superior half of anterior radius	Bodies of middle phalanges of medial four digits	Median nerve	Flexes middle and proximal phalanges of medial four digits, flexes hand at wrist	Ulnar and radial arteries	Anterior forearm
Flexor pollicis brevis	Flexor retinaculum and tubercle of trapezium	Lateral side of base of proximal phalanx of thumb	Median nerve (recurrent branch)	Flexes proximal phalanx of thumb	Superficial palmar branch of radial artery	Hand
Flexor pollicis longus	Anterior surface of radius and interosseous membrane	Palmar base of distal phalanx of thumb	Median nerve (anterior interosseous)	Flexes phalanges of thumb	Anterior interosseous artery	Anterior forearm
Infraspinatus	Infraspinous fossa of scapula and deep fascia	Middle facet of greater tubercle of humerus	Suprascapular nerve	Lateral rotation of arm (with teres minor)	Suprascapular artery	Shoulder

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Latissimus dorsi	Spinous processes of T7–L5 vertebrae, thoracolumbar fascia, iliac crest, last 3 ribs	Intertubercular sulcus of humerus	Thoracodorsal nerve	Extends, adducts, and medially rotates humerus at shoulder	Thoracodorsal artery, dorsal perforating branches of 9th, 10th, and 11th posterior intercostal, subcostal, and first three lumbar arteries	Shoulder
Levator scapulae	Posterior tubercles of transverse processes of C1–C4	Medial border of scapula from superior angle to spine	Ventral rami of C3–C4 and dorsal scapular nerve	Elevates scapula medially, inferiorly rotates glenoid cavity	Dorsal scapular artery, transverse cervical artery, ascending cervical artery	Superficial back
Lumbrical, first and second	Lateral two tendons of flexor digitorum profundus	Lateral sides of extensor expansion of digits 2 and 3	Median nerve (digital branches)	Extend digits at interphalangeal joints, flex metacarpophalangeal joints	Superficial and deep palmar arches	Hand
Lumbrical, third and fourth	Medial three tendons of flexor digitorum profundus	Lateral sides of extensor expansion of digits 4 and 5	Ulnar nerve (deep branch)	Extend digits at interphalangeal joints, flex metacarpophalangeal joints	Superficial and deep palmar arches	Hand
Opponens digiti minimi	Flexor retinaculum and hook of hamate bone	Palmar surface of 5th metacarpal	Ulnar nerve (deep branch)	Draws 5th metacarpal anteriorly and rotates it to face thumb	Deep palmar branch of ulnar artery	Hand
Opponens pollicis	Flexor retinaculum and tubercle of trapezium	Lateral side of 1st metacarpal	Median nerve (recurrent branch)	Draws 1st metacarpal forward and rotates it medially	Superficial palmar branch of radial artery	Hand
Palmar interosseous muscles	Sides of metacarpals 2, 4, and 5	Bases of proximal phalanx and extensor expansion of digits 2, 4, and 5	Ulnar nerve (deep branch)	Adducts digits toward axial line of hand (3rd digit); flexes digits at metacarpophalngeal joint and extends interphalangeal joints	Deep palmar arch	Hand
Palmaris brevis	Palmar aponeurosis and flexor retinaculum	Skin of medial border of palm	Superficial palmar branch of ulnar nerve	Deepens hollow of hand, assists grip	Superficial palmar arch	Hand
Palmaris longus	Medial epicondyle of humerus	Distal half of flexor retinaculum and palmar aponeurosis	Median nerve	Flexes hand at wrist and tenses palmar aponeurosis	Posterior ulnar recurrent artery	Anterior forearm
Pectoralis major	Sternal half of clavicle, sternum to 7th rib, cartilages of true ribs, aponeurosis of external oblique muscle	Lateral lip of intertubercular sulcus of humerus	Medial and lateral pectoral nerves	Flexes and adducts arm, rotates arm medially	Pectoral branch of thoraco-acromial artery, perforating branches of internal thoracic artery	Pectoral region/ axilla
Pectoralis minor	Outer surface of upper margin of ribs 3–5	Coracoid process of scapula	Medial pectoral nerve	Lowers lateral angle of scapula and protracts scapula	Pectoral branch of thoraco-acromial and intercostal lateral thoracic arteries	Pectoral region/ axilla
Pronator quadratus	Distal fourth of anterior ulna	Distal fourth of anterior radius	Median nerve (anterior interosseous)	Pronates forearm	Anterior interosseous artery	Anterior forearm
Pronator teres	Two heads: medial epicondyle of humerus and coronoid process of ulna	Midway along lateral surface of radius	Median nerve	Pronates forearm and assists with elbow flexion	Anterior ulnar recurrent artery	Anterior forearm

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Rhomboid major	Spinous processes of T2–T5 vertebrae	Medial border of scapula below base of spine of scapula	Dorsal scapular nerve	Fixes scapula to thoracic wall and retracts and rotates it to depress glenoid cavity	Dorsal scapular OR deep branch of transverse cervical artery, dorsal perforating branches of the upper five or six posterior intercostal arteries artery	Superficial back
Rhomboid minor	Ligamentum nuchae, spines of C7 and T1 vertebrae	Medial border of scapula at spine of scapula	Dorsal scapular nerve	Fixes scapula to thoracic wall and retracts and rotates it to depress glenoid cavity	Dorsal scapular artery OR deep branch of transverse cervical artery, dorsal perforating branches of the upper five or six posterior intercostal arteries	Superficial back
Serratus anterior	Lateral surfaces of upper 8–9 ribs	Costal surface of medial border of scapula	Long thoracic nerve	Protracts and rotates scapula and holds it against thoracic wall	Lateral thoracic artery	Shoulder
Subclavius	Upper border of 1st rib and its cartilage	Inferior surface of middle third of clavicle	Nerve to subclavius	Anchors and depresses clavicle	Clavicular branch of thoraco-acromial artery	Shoulder
Subscapularis	Subscapular fossa	Lesser tubercle of humerus	Upper and lower subscapular nerves	Medially rotates arm at shoulder and adducts it, helps hold humeral head in glenoid cavity	Subscapular artery, lateral thoracic artery	Shoulder
Supinator	Lateral epicondyle of humerus, supinator crest of ulna	Lateral, posterior, and anterior surfaces of proximal third of radius	Radial nerve (deep branch)	Supinates forearm	Radial recurrent artery, posterior interosseous arteries	Posterior forearm
Supraspinatus	Supraspinous fossa of scapula and deep fascia	Superior facet of greater tubercle of humerus	Suprascapular nerve	Initiates arm abduction, acts with rotator cuff muscles	Suprascapular artery	Shoulder
Teres major	Posterior surface of inferior angle of scapula	Medial lip of intertubercular sulcus of humerus	Lower subscapular nerve	Adducts and medially rotates arm	Circumflex scapular artery	Shoulder
Teres minor	Upper 2/3 of posterior surface of lateral border of scapula	Inferior facet of greater tubercle of humerus	Axillary nerve	Laterally rotates arm	Circumflex scapular artery	Shoulder
Trapezius	Superior nuchal line, external occipital protuberance, nuchal ligament, spinous processes of C7–T12	Lateral third of clavicle, acromion, and spine of scapula	Accessory nerve (cranial nerve XI)	Elevates, retracts, and rotates scapula; lower fibers depress scapula	Transverse cervical artery, dorsal perforating branches of posterior intercostal arteries	Superficial back
Triceps brachii	*Long head:* infraglenoid tubercle of scapula *Lateral head:* upper half of posterior humerus *Medial head:* distal 2/3 of medial and posterior humerus	Posterior surface of olecranon process of ulna	Radial nerve	Extends forearm at elbow; long head stabilizes head of abducted humerus and extends and adducts arm at shoulder	Branch of profunda brachii artery	Arm



Section

7 LOWER LIMB

Topographic Anatomy
Plate 468

468 Lower Limb: Surface Anatomy

Cutaneous Anatomy
Plates 469–472

469 Dermatomes of Lower Limb

470 Superficial Nerves and Veins of Lower Limb: Anterior View

471 Superficial Nerves and Veins of Lower Limb: Posterior View

472 Lymph Vessels and Nodes of Lower Limb

Hip and Thigh
Plates 473–492

473 Hip (Coxal) Bone

474 Hip Joint

475 Hip Joint: Anteroposterior Radiograph

476 Femur

477 Bony Attachments of Muscles of Hip and Thigh: Anterior View

478 Bony Attachments of Muscles of Hip and Thigh: Posterior View

479 Muscles of Thigh: Anterior Views

480 Muscles of Thigh: Anterior Views (continued)

481 Muscles of Hip and Thigh: Lateral View

482 Muscles of Hip and Thigh: Posterior Views

483 Psoas and Iliacus Muscles

484 Lumbosacral and Coccygeal Plexuses
485 Lumbar Plexus
486 Sacral and Coccygeal Plexuses
487 Arteries and Nerves of Thigh: Anterior Views
488 Arteries and Nerves of Thigh: Anterior Views (continued)
489 Arteries and Nerves of Thigh: Posterior View
490 Nerves of Hip and Buttock
491 Arteries of Femoral Head and Neck
492 Thigh: Serial Cross Sections

Knee

Plates 493–499

493 Knee: Medial and Lateral Views
494 Knee: Anterior Views
495 Knee: Interior
496 Knee: Cruciate and Collateral Ligaments
497 Knee: Anteroposterior Radiograph and Posterior View
498 Knee: Posterior and Sagittal Views
499 Arteries of Thigh and Knee: Schema

Leg

Plates 500–510

500 Tibia and Fibula
501 Tibia and Fibula (continued)
502 Attachments of Muscles of Leg
503 Muscles of Leg (Superficial Dissection): Posterior View
504 Muscles of Leg (Intermediate Dissection): Posterior View
505 Muscles of Leg (Deep Dissection): Posterior View
506 Muscles of Leg: Lateral View
507 Muscles of Leg (Superficial Dissection): Anterior View
508 Muscles of Leg (Deep Dissection): Anterior View
509 Arteries of Knee, Leg, and Foot
510 Leg: Cross Sections and Fascial Compartments

Ankle and Foot

Plates 511–524

511 Bones of Foot
512 Bones of Foot (continued)
513 Calcaneus
514 Ligaments and Tendons of Ankle
515 Ligaments and Tendons of Foot: Plantar View
516 Tendon Sheaths of Ankle
517 Muscles of Dorsum of Foot: Superficial Dissection
518 Dorsum of Foot: Deep Dissection
519 Sole of Foot: Superficial Dissection
520 Muscles of Sole of Foot: First Layer
521 Muscles of Sole of Foot: Second Layer
522 Muscles of Sole of Foot: Third Layer
523 Interosseous Muscles and Deep Arteries of Foot
524 Interosseous Muscles of Foot

Neurovasculature

Plates 525–529

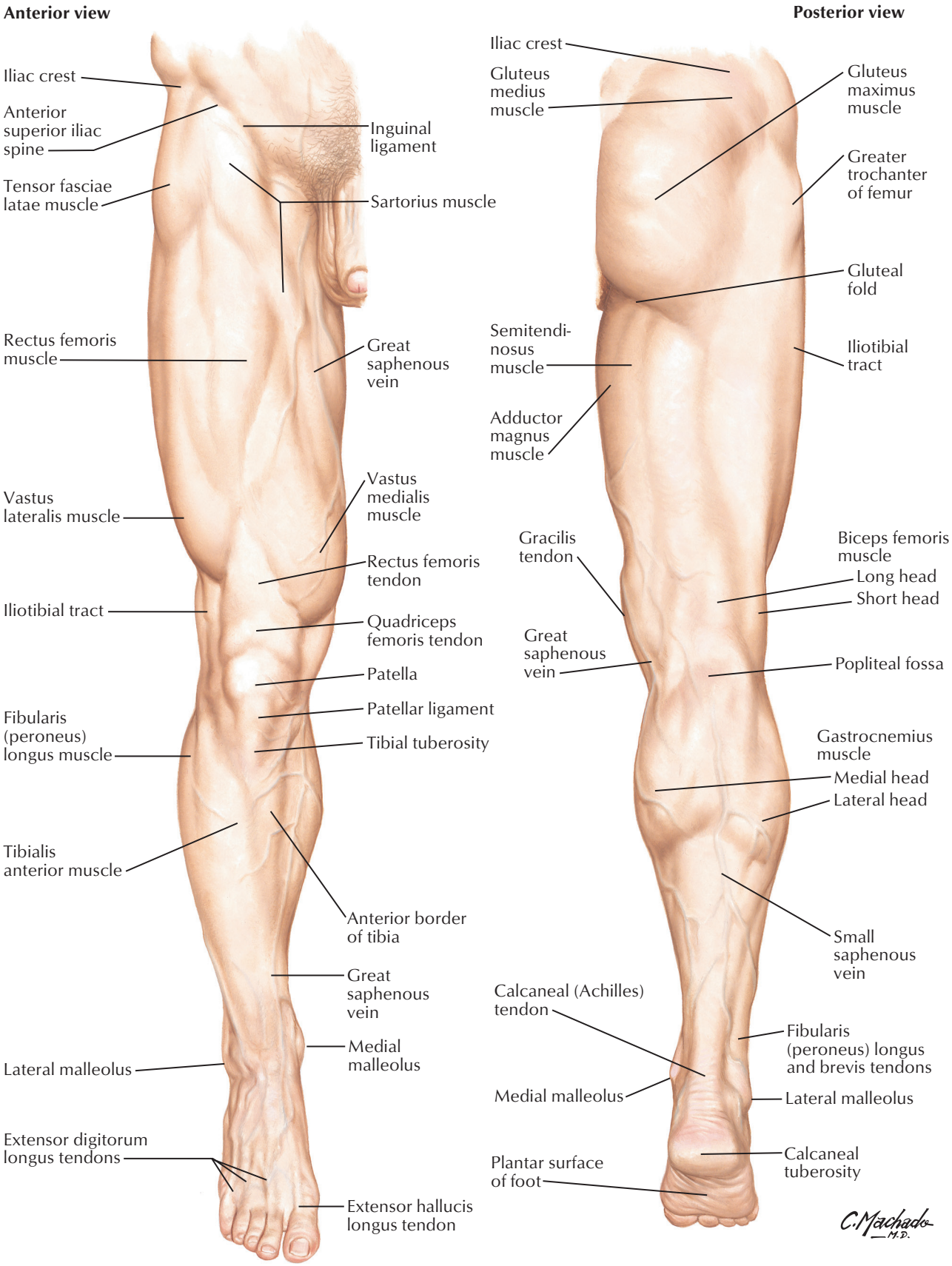
525 Femoral Nerve and Lateral Cutaneous Nerve of Thigh
526 Obturator Nerve
527 Sciatic Nerve and Posterior Cutaneous Nerve of Thigh
528 Tibial Nerve
529 Common Fibular (Peroneal) Nerve

Regional Scans

Plates 530–531

530 Hip Radiograph, Arthrogram, and MRI
531 Ankle: Radiographs

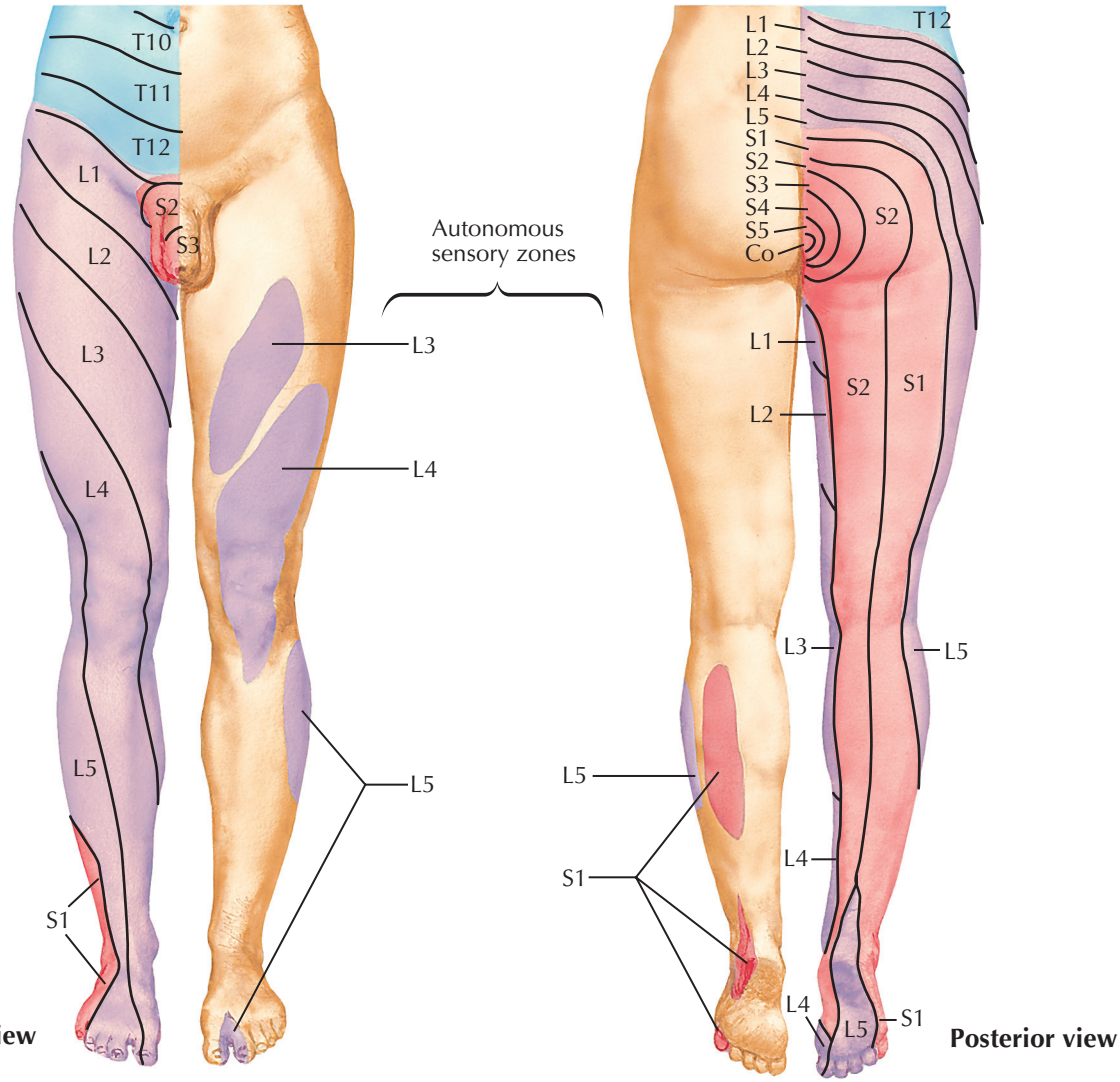
Muscle Tables


Anterior view
Iliac crest
Anterior superior iliac spine
Tensor fasciae latae muscle
Inguinal ligament
Sartorius muscle
Rectus femoris muscle
Great saphenous vein
Vastus lateralis muscle
Vastus medialis muscle
Rectus femoris tendon
Iliotibial tract
Quadriceps femoris tendon
Patella
Patellar ligament
Fibularis (peroneus) longus muscle
Tibial tuberosity
Tibialis anterior muscle
Anterior border of tibia
Great saphenous vein
Medial malleolus
Lateral malleolus
Extensor digitorum longus tendons
Extensor hallucis longus tendon
Posterior view
Iliac crest
Gluteus medius muscle
Gluteus maximus muscle
Greater trochanter of femur
Gluteal fold
Semitendinosus muscle
Iliotibial tract
Adductor magnus muscle
Gracilis tendon
Biceps femoris muscle
Long head
Short head
Great saphenous vein
Popliteal fossa
Gastrocnemius muscle
Medial head
Lateral head
Small saphenous vein
Calcaneal (Achilles) tendon
Fibularis (peroneus) longus and brevis tendons
Medial malleolus
Lateral malleolus
Calcaneal tuberosity
Plantar surface of foot
C. Machado M.D.

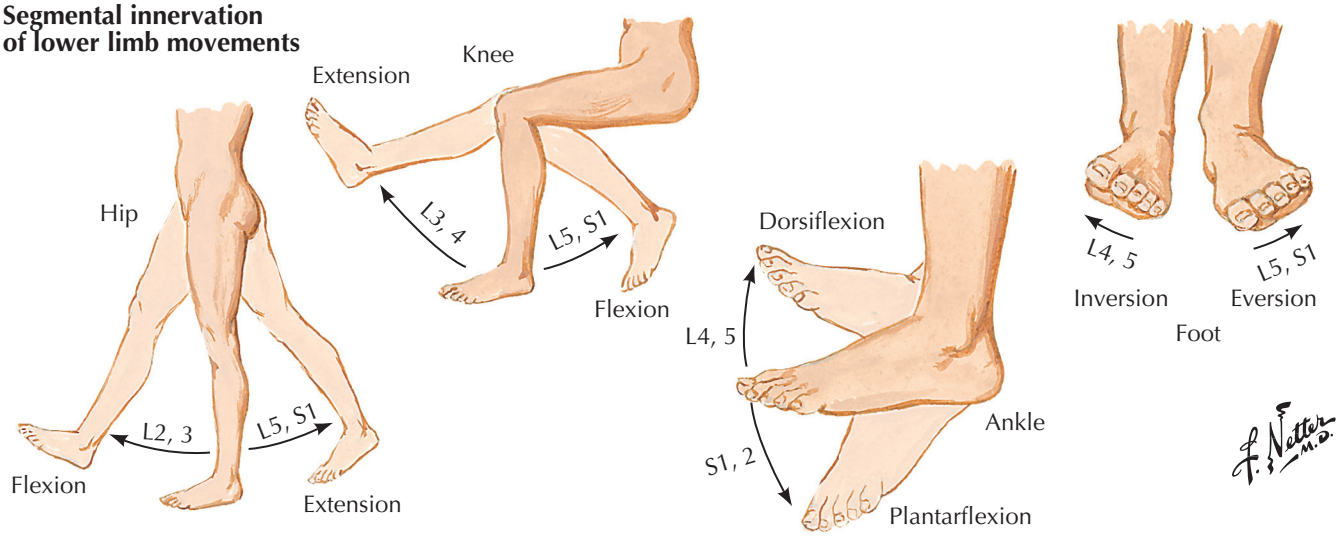
Dermatomes of Lower Limb

See also **Plate 162**

Schematic demarcation of dermatomes (according to Keegan and Garrett) shown as distinct segments. There is actually considerable overlap between any two adjacent dermatomes.

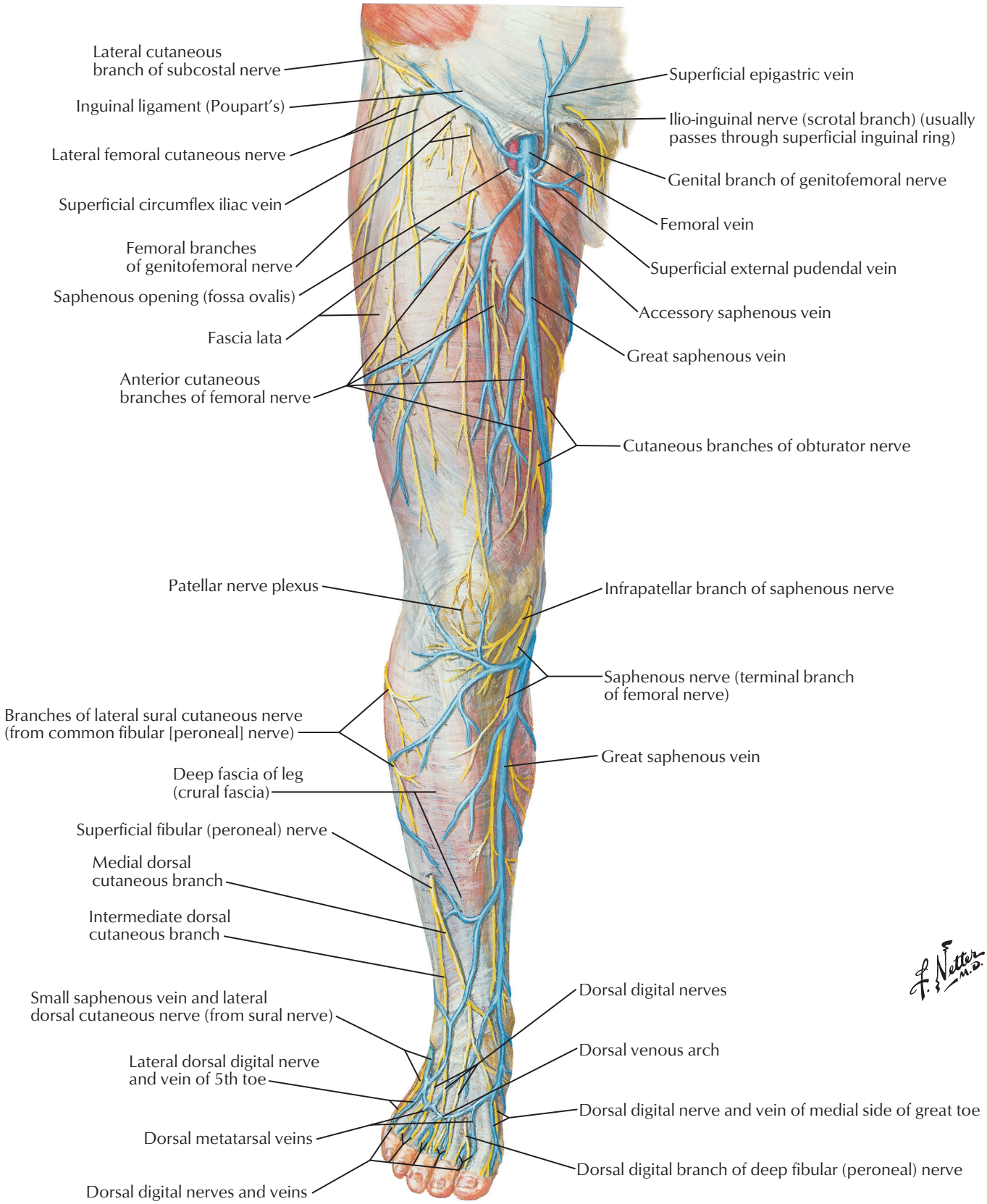


Segmental innervation of lower limb movements



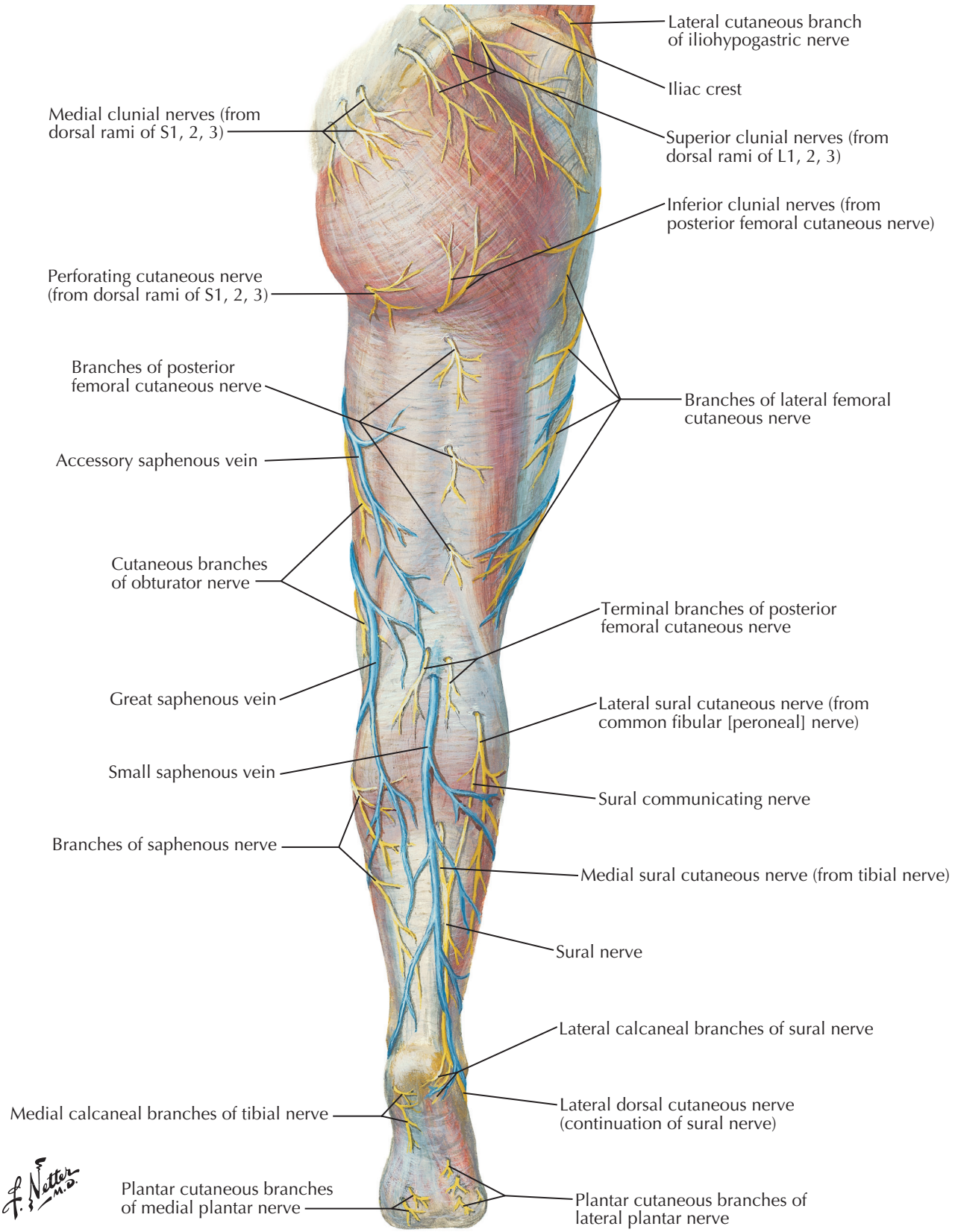
Superficial Nerves and Veins of Lower Limb: Anterior View

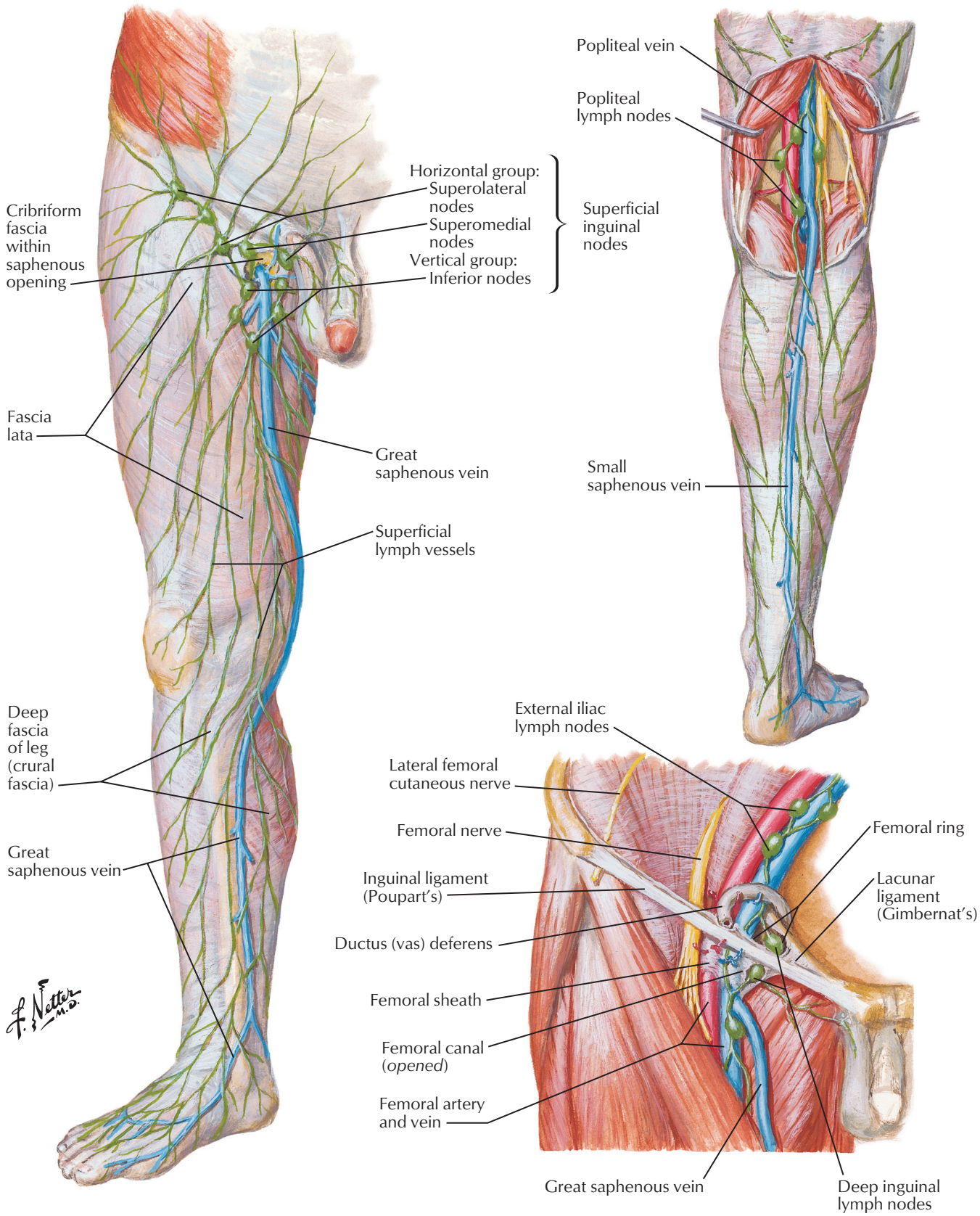
See also Plates 525, 526, 529

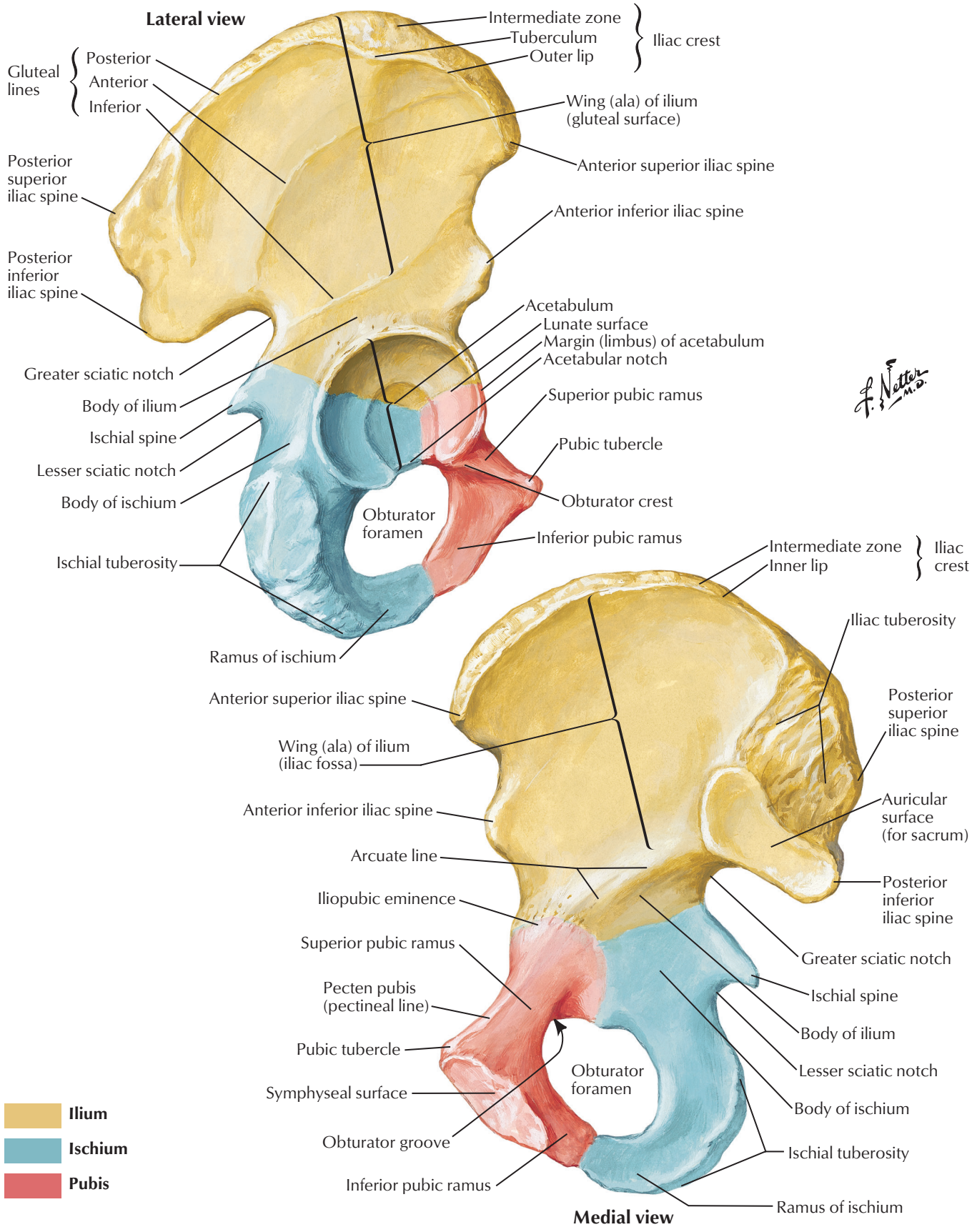


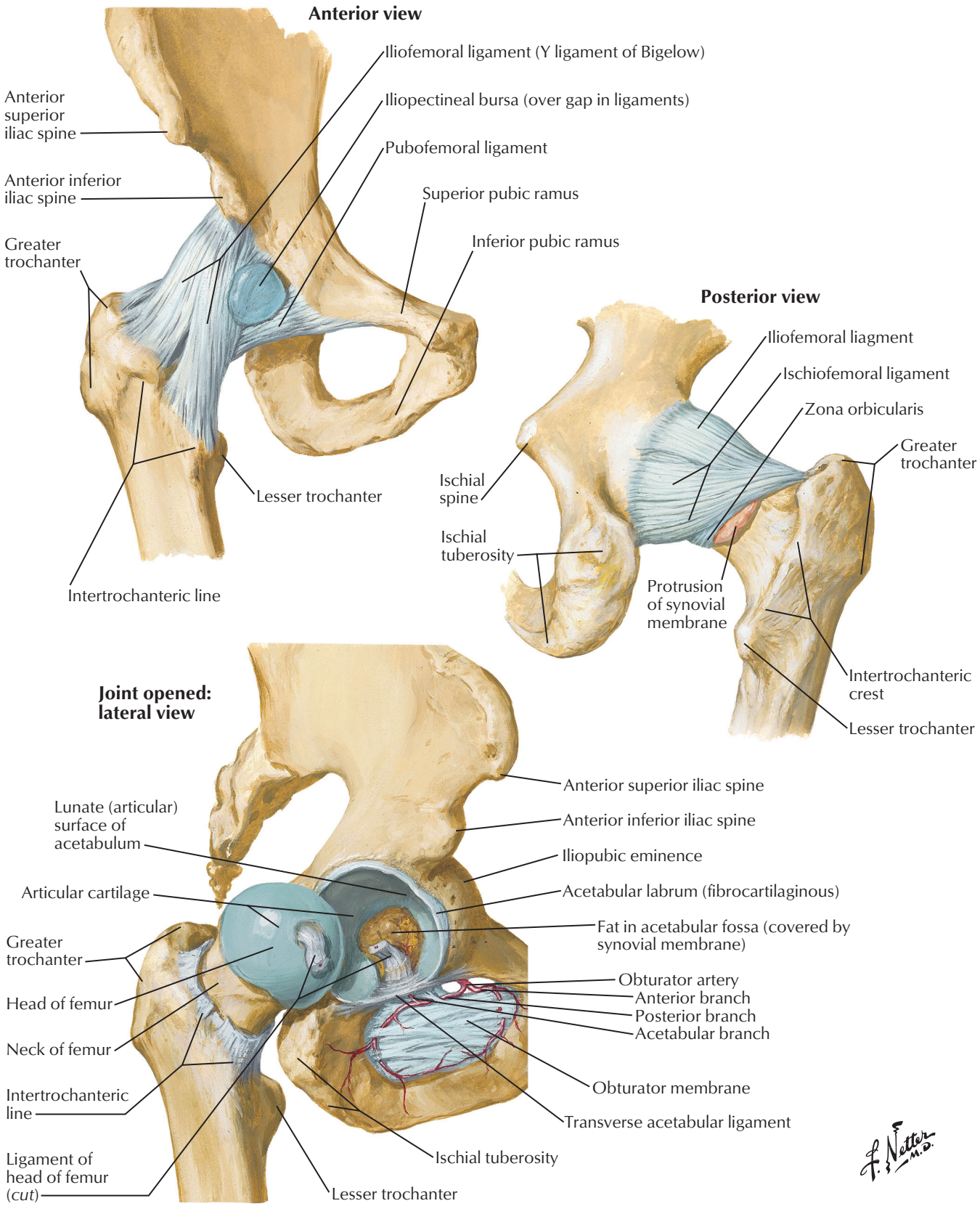
Superficial Nerves and Veins of Lower Limb: Posterior View

See also Plates 527, 528



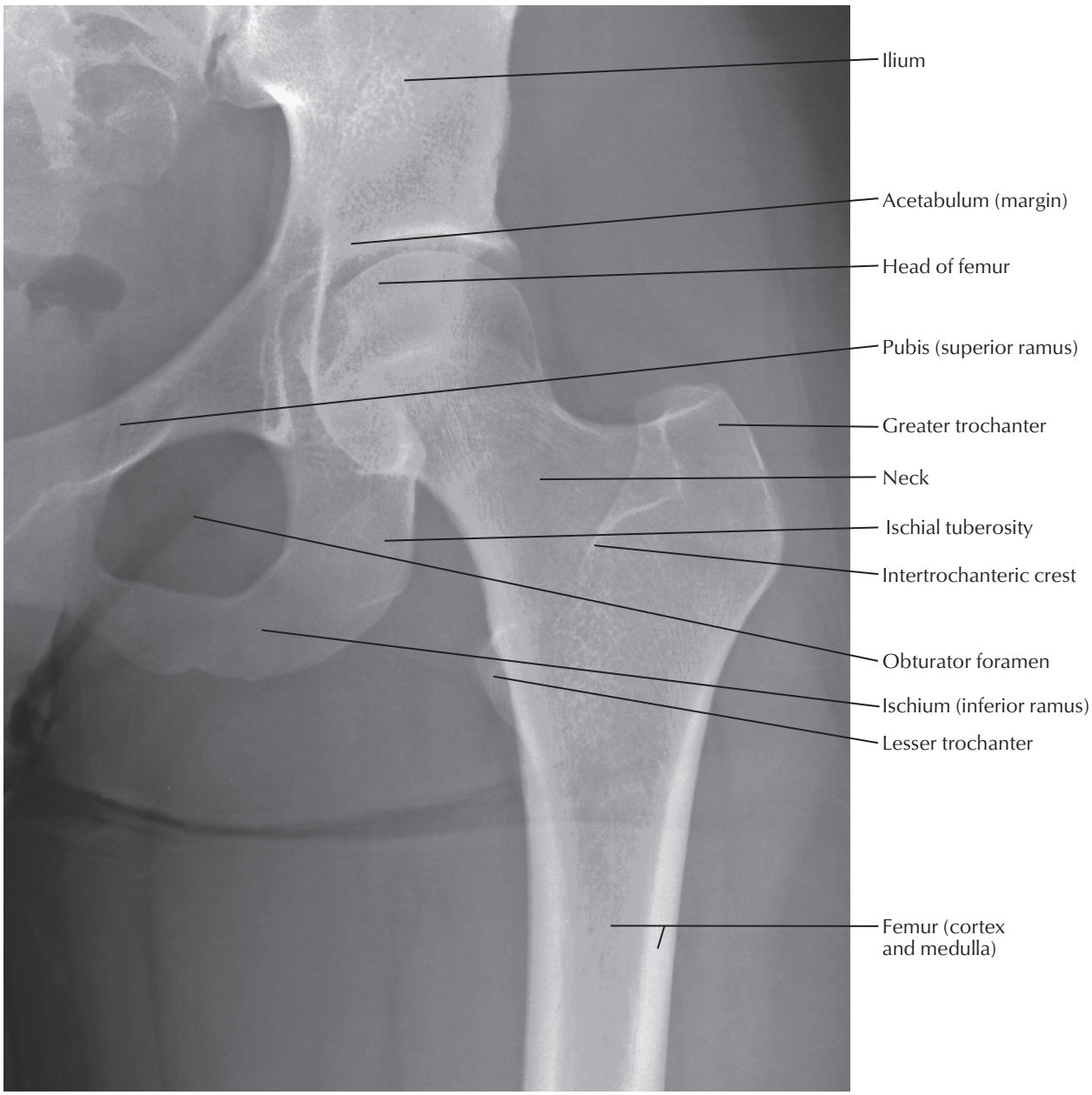

Cribriform fascia within saphenous opening
Horizontal group:
Superolateral nodes
Superomedial nodes
Vertical group:
Inferior nodes
Fascia lata
Great saphenous vein
Superficial lymph vessels
Deep fascia of leg (crural fascia)
Great saphenous vein
Popliteal vein
Popliteal lymph nodes
Superficial inguinal nodes
Small saphenous vein
External iliac lymph nodes
Lateral femoral cutaneous nerve
Femoral nerve
Inguinal ligament (Poupart's)
Ductus (vas) deferens
Femoral sheath
Femoral canal (*opened*)
Femoral artery and vein
Femoral ring
Lacunar ligament (Gimbernat's)
Great saphenous vein
Deep inguinal lymph nodes

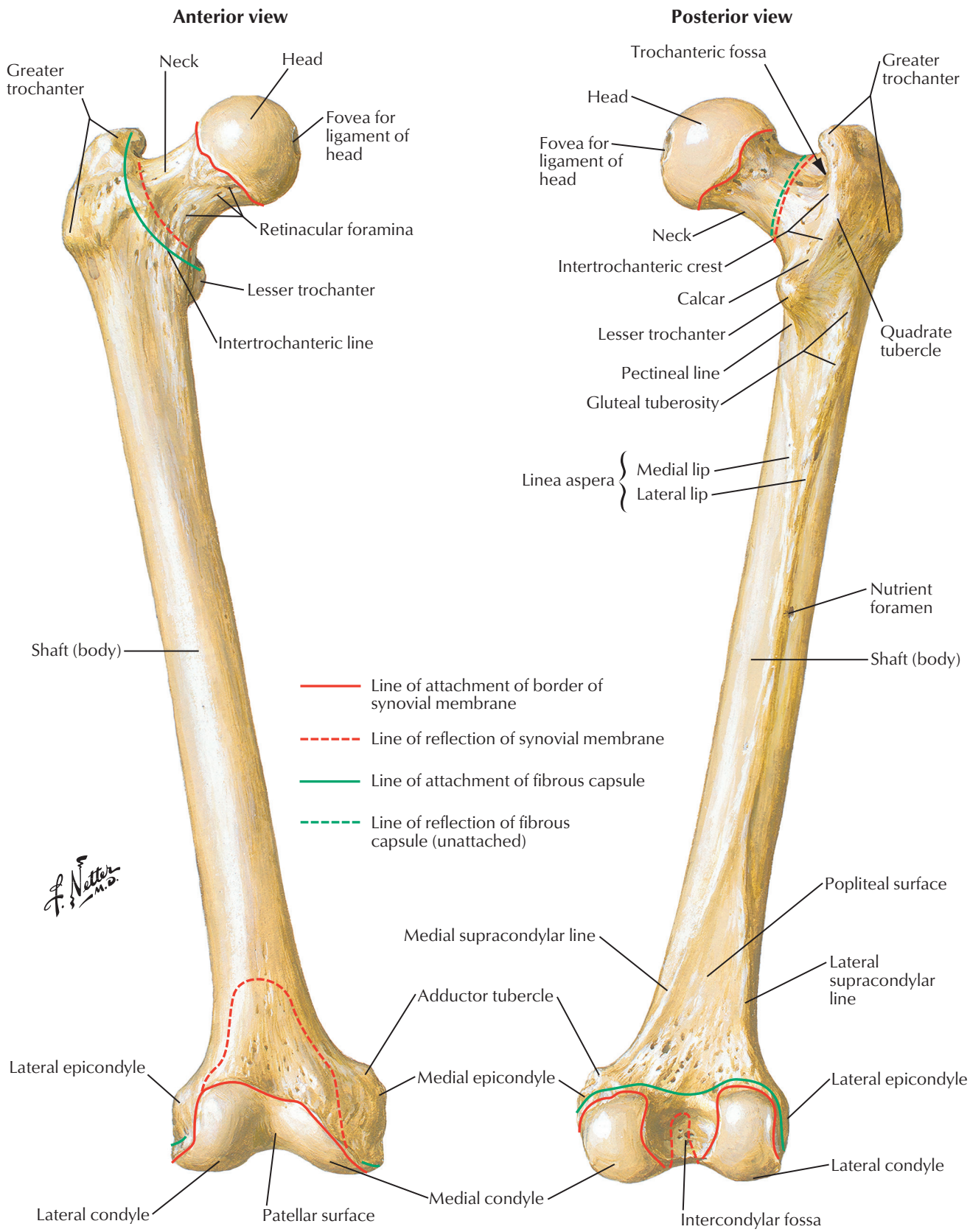

Lateral view
Intermediate zone
Tuberculum
Outer lip
Iliac crest
Gluteal lines
Posterior
Anterior
Inferior
Wing (ala) of ilium (gluteal surface)
Anterior superior iliac spine
Posterior superior iliac spine
Anterior inferior iliac spine
Posterior inferior iliac spine
Acetabulum
Lunate surface
Margin (limbus) of acetabulum
Acetabular notch
Greater sciatic notch
Body of ilium
Superior pubic ramus
Ischial spine
Pubic tubercle
Lesser sciatic notch
Obturator crest
Body of ischium
Obturator foramen
Inferior pubic ramus
Ischial tuberosity
Ramus of ischium
Intermediate zone
Inner lip
Iliac crest
Iliac tuberosity
Anterior superior iliac spine
Posterior superior iliac spine
Wing (ala) of ilium (iliac fossa)
Anterior inferior iliac spine
Auricular surface (for sacrum)
Arcuate line
Posterior inferior iliac spine
Iliopubic eminence
Greater sciatic notch
Superior pubic ramus
Ischial spine
Pecten pubis (pectineal line)
Body of ilium
Pubic tubercle
Lesser sciatic notch
Obturator foramen
Symphyseal surface
Body of ischium
Obturator groove
Ischial tuberosity
Inferior pubic ramus
Ramus of ischium
Medial view
Ilium
Ischium
Pubis


Anterior view
Iliofemoral ligament (Y ligament of Bigelow)
Iliopectineal bursa (over gap in ligaments)
Pubofemoral ligament
Superior pubic ramus
Inferior pubic ramus
Anterior superior iliac spine
Anterior inferior iliac spine
Greater trochanter
Lesser trochanter
Intertrochanteric line
Posterior view
Iliofemoral liagment
Ischiofemoral ligament
Zona orbicularis
Greater trochanter
Ischial spine
Ischial tuberosity
Protrusion of synovial membrane
Intertrochanteric crest
Lesser trochanter
Joint opened: lateral view
Anterior superior iliac spine
Anterior inferior iliac spine
Iliopubic eminence
Acetabular labrum (fibrocartilaginous)
Fat in acetabular fossa (covered by synovial membrane)
Obturator artery
Anterior branch
Posterior branch
Acetabular branch
Obturator membrane
Transverse acetabular ligament
Ischial tuberosity
Lesser trochanter
Lunate (articular) surface of acetabulum
Articular cartilage
Greater trochanter
Head of femur
Neck of femur
Intertrochanteric line
Ligament of head of femur (cut)

Hip Joint: Anteroposterior Radiograph

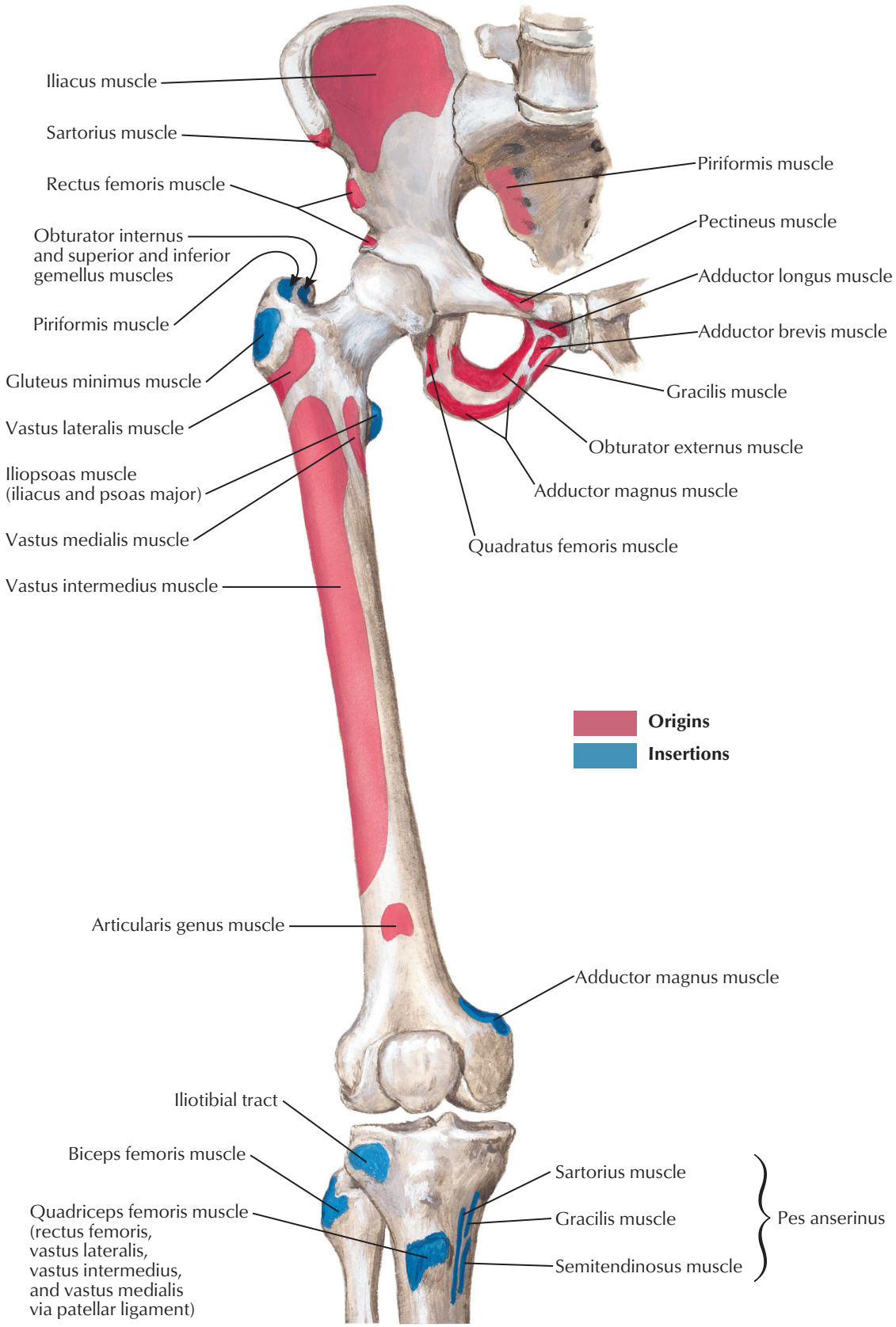
See also **Plates 331, 474, 478**




Anterior view
Greater trochanter
Neck
Head
Fovea for ligament of head
Retinacular foramina
Lesser trochanter
Intertrochanteric line
Shaft (body)
Lateral epicondyle
Lateral condyle
Patellar surface
Medial condyle
Adductor tubercle
Medial epicondyle
Posterior view
Trochanteric fossa
Greater trochanter
Head
Fovea for ligament of head
Neck
Intertrochanteric crest
Calcar
Lesser trochanter
Pectineal line
Gluteal tuberosity
Quadrate tubercle
Linea aspera
Medial lip
Lateral lip
Nutrient foramen
Shaft (body)
Popliteal surface
Medial supracondylar line
Lateral supracondylar line
Lateral epicondyle
Lateral condyle
Intercondylar fossa
Line of attachment of border of synovial membrane
Line of reflection of synovial membrane
Line of attachment of fibrous capsule
Line of reflection of fibrous capsule (unattached)

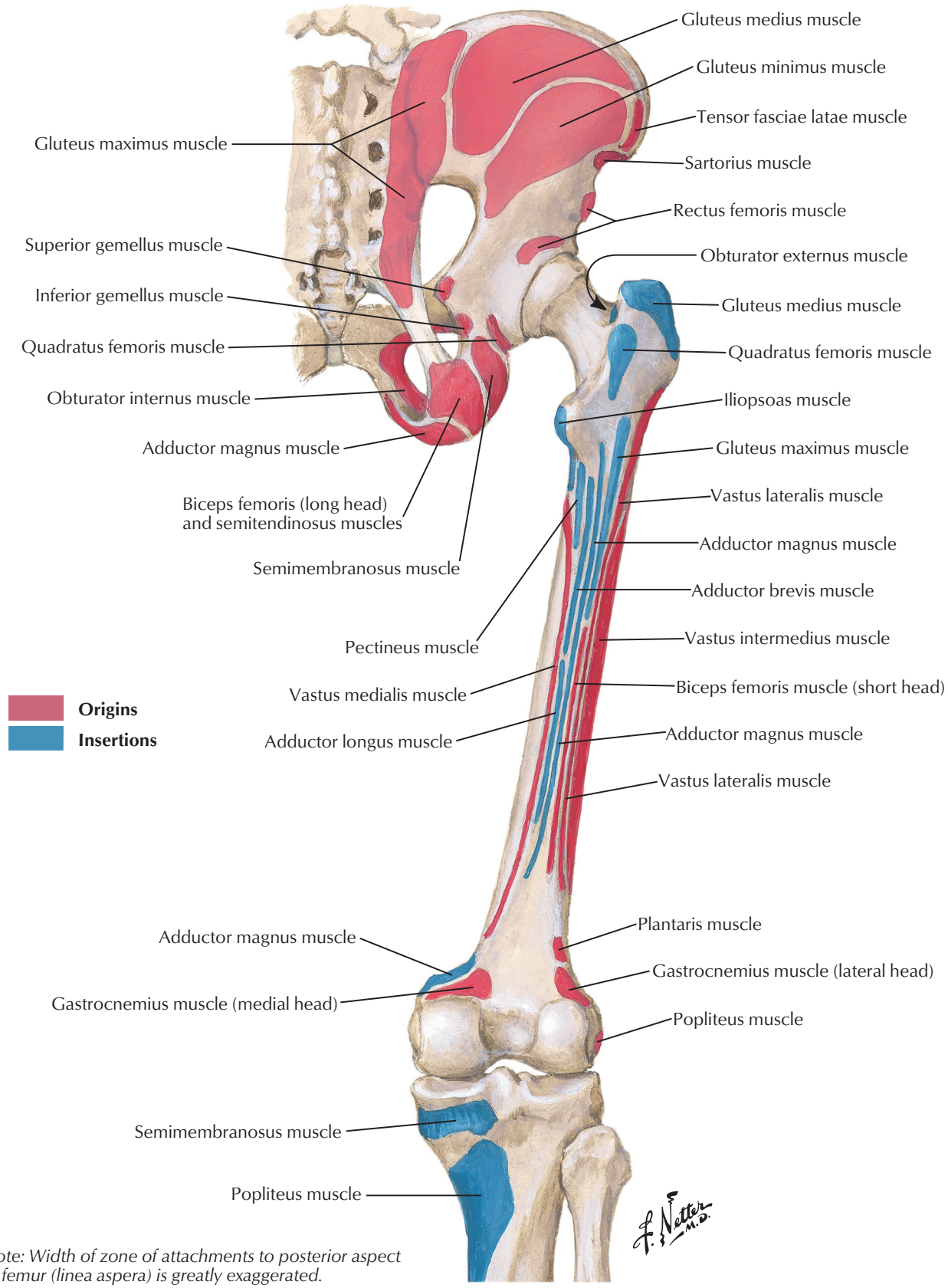
Bony Attachments of Muscles of Hip and Thigh: Anterior View

See also Plate 530



Bony Attachments of Muscles of Hip and Thigh: Posterior View

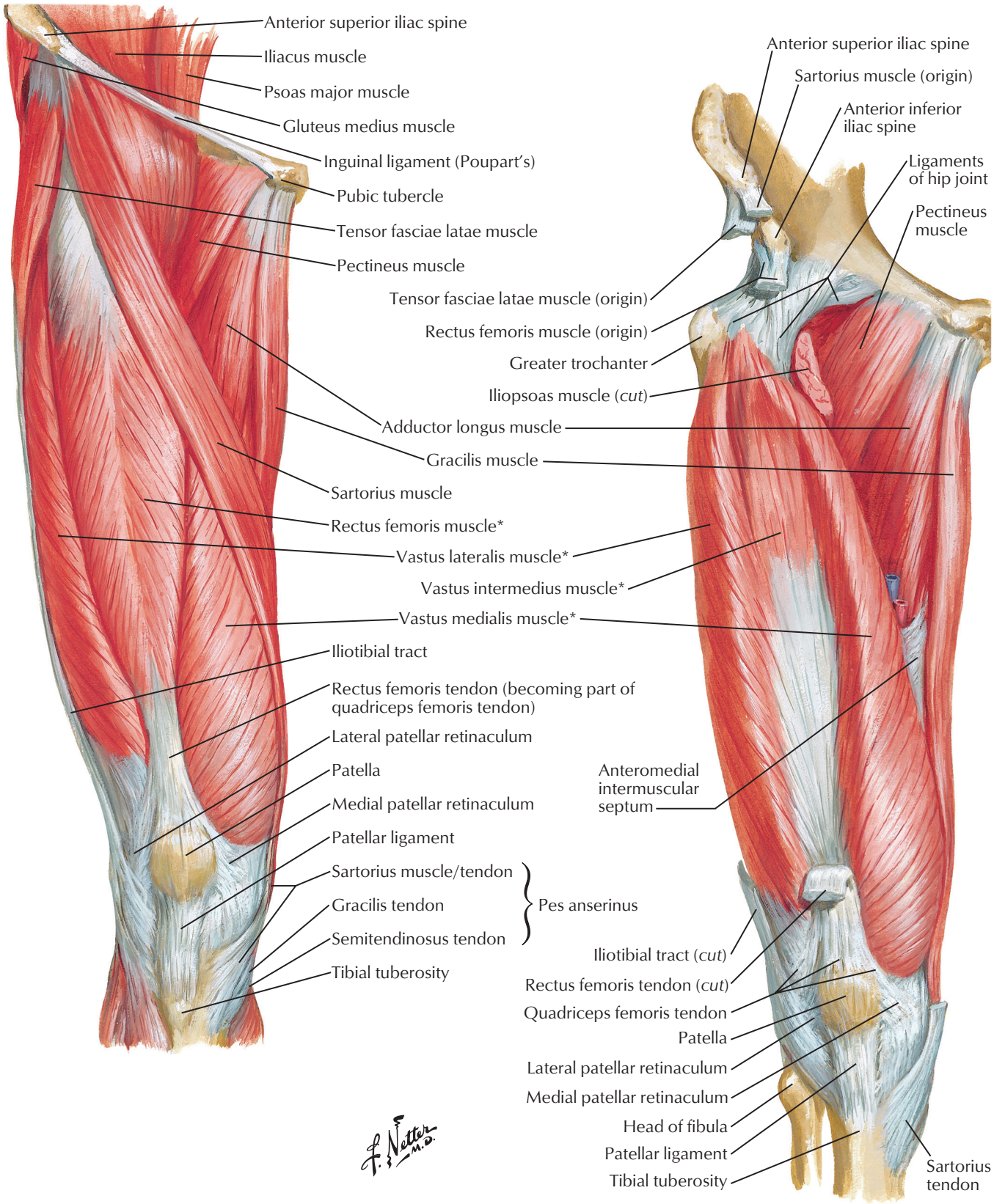
See also Plate 475



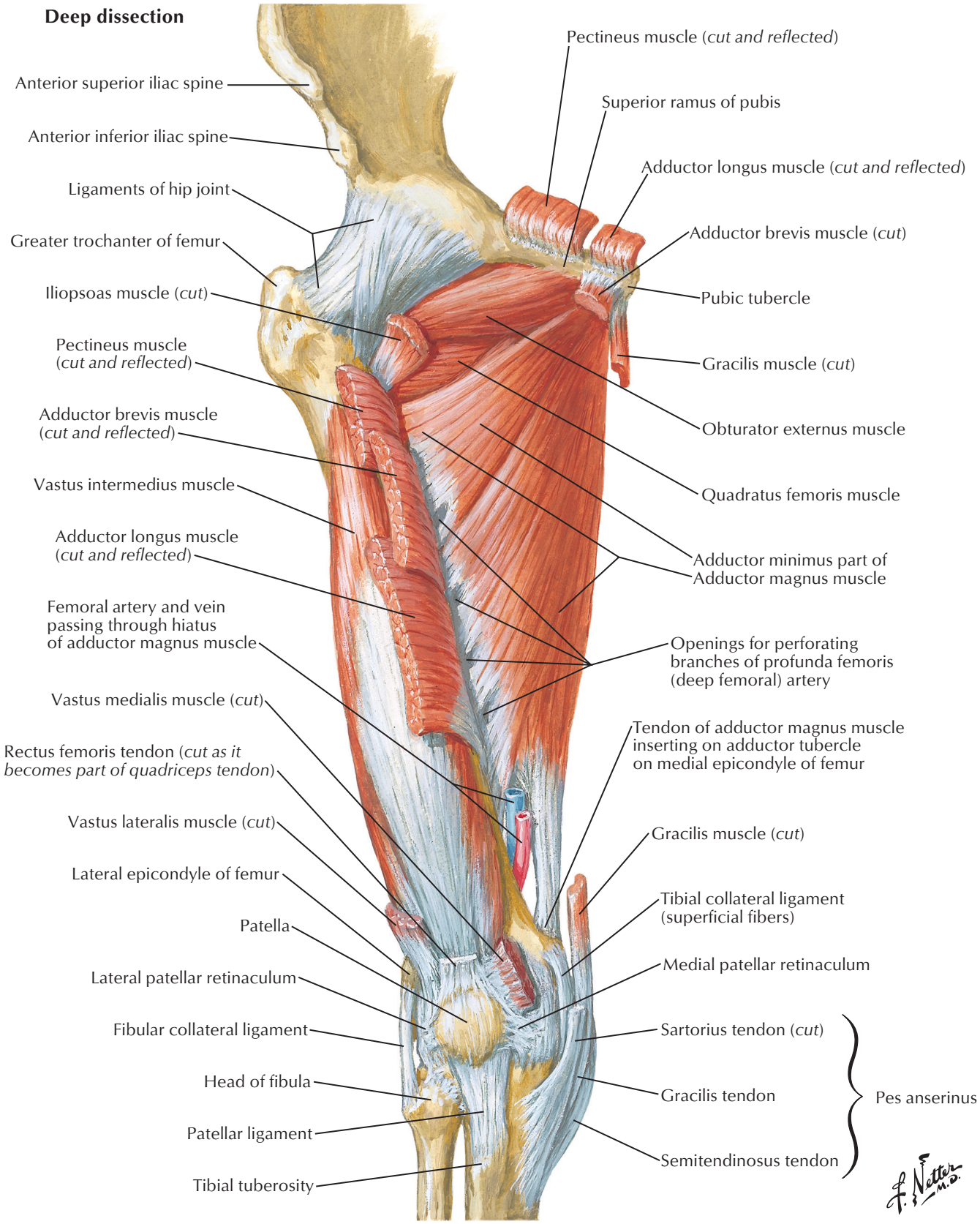
Note: Width of zone of attachments to posterior aspect of femur (linea aspera) is greatly exaggerated.

Muscles of Thigh: Anterior Views

See also **Plate 258**

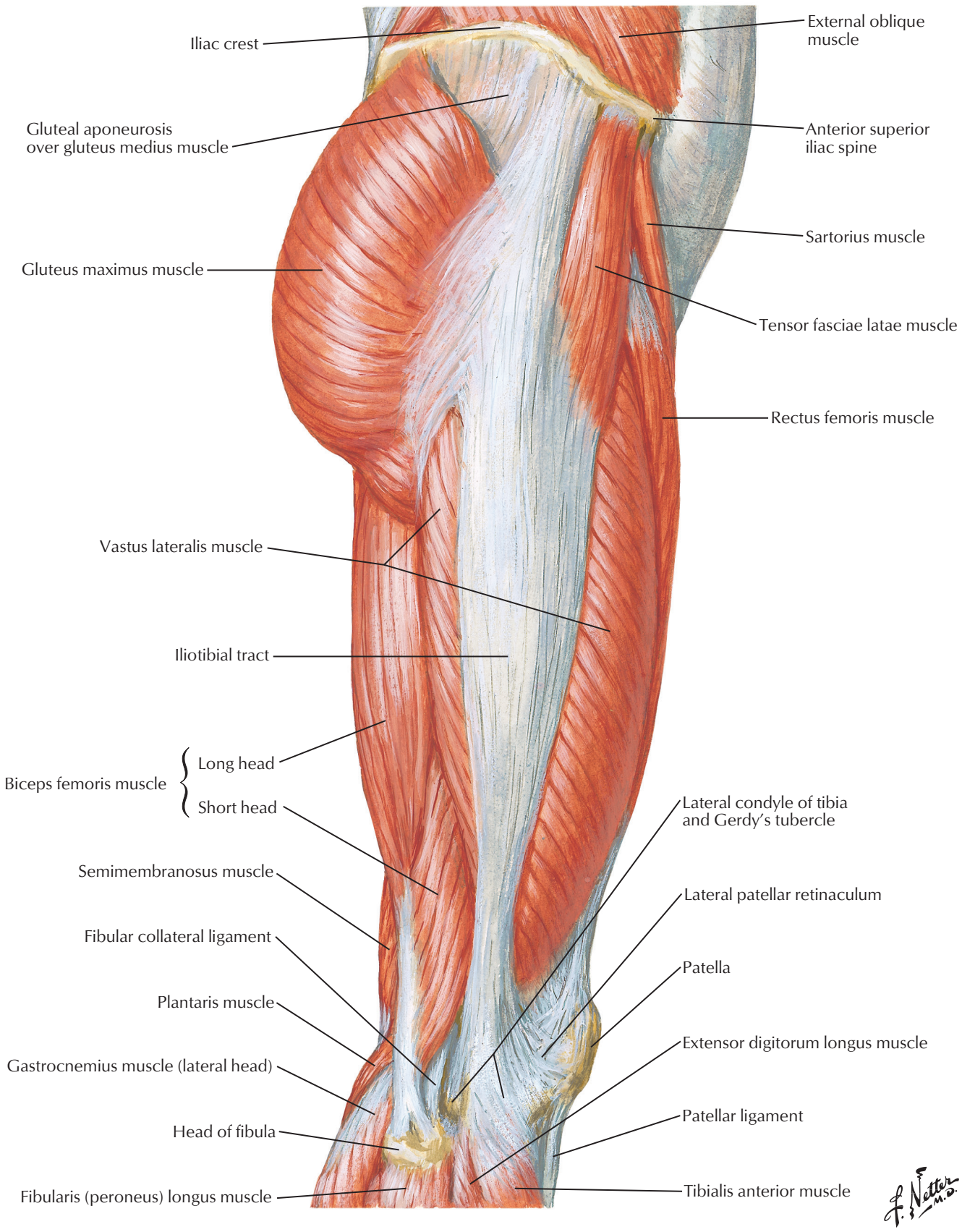


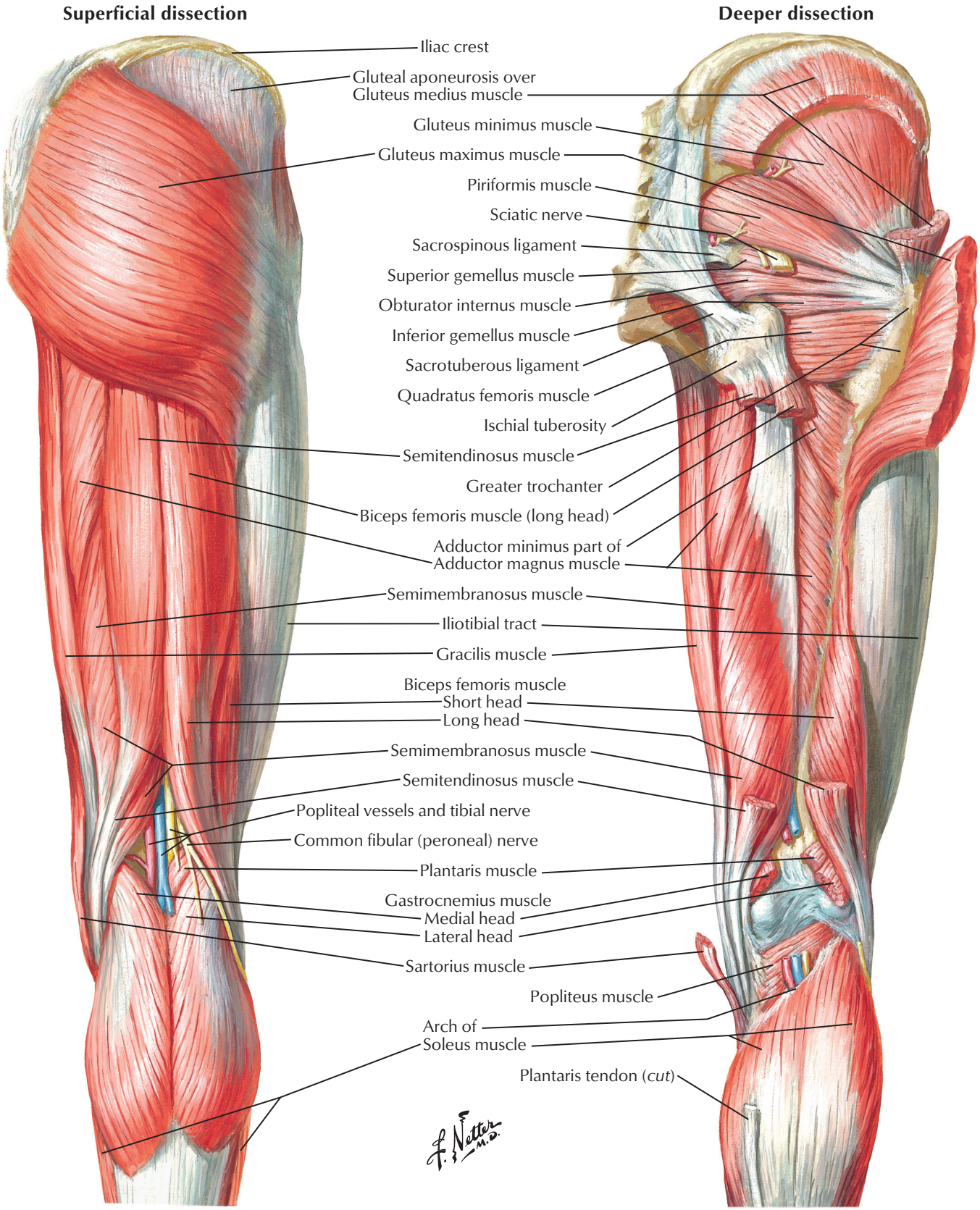
*Muscles of quadriceps femoris


Deep dissection
Anterior superior iliac spine
Anterior inferior iliac spine
Ligaments of hip joint
Greater trochanter of femur
Iliopsoas muscle (cut)
Pectineus muscle (cut and reflected)
Adductor brevis muscle (cut and reflected)
Vastus intermedius muscle
Adductor longus muscle (cut and reflected)
Femoral artery and vein passing through hiatus of adductor magnus muscle
Vastus medialis muscle (cut)
Rectus femoris tendon (cut as it becomes part of quadriceps tendon)
Vastus lateralis muscle (cut)
Lateral epicondyle of femur
Patella
Lateral patellar retinaculum
Fibular collateral ligament
Head of fibula
Patellar ligament
Tibial tuberosity
Pectineus muscle (cut and reflected)
Superior ramus of pubis
Adductor longus muscle (cut and reflected)
Adductor brevis muscle (cut)
Pubic tubercle
Gracilis muscle (cut)
Obturator externus muscle
Quadratus femoris muscle
Adductor minimus part of Adductor magnus muscle
Openings for perforating branches of profunda femoris (deep femoral) artery
Tendon of adductor magnus muscle inserting on adductor tubercle on medial epicondyle of femur
Gracilis muscle (cut)
Tibial collateral ligament (superficial fibers)
Medial patellar retinaculum
Sartorius tendon (cut)
Gracilis tendon
Semitendinosus tendon
Pes anserinus

Muscles of Hip and Thigh: Lateral View

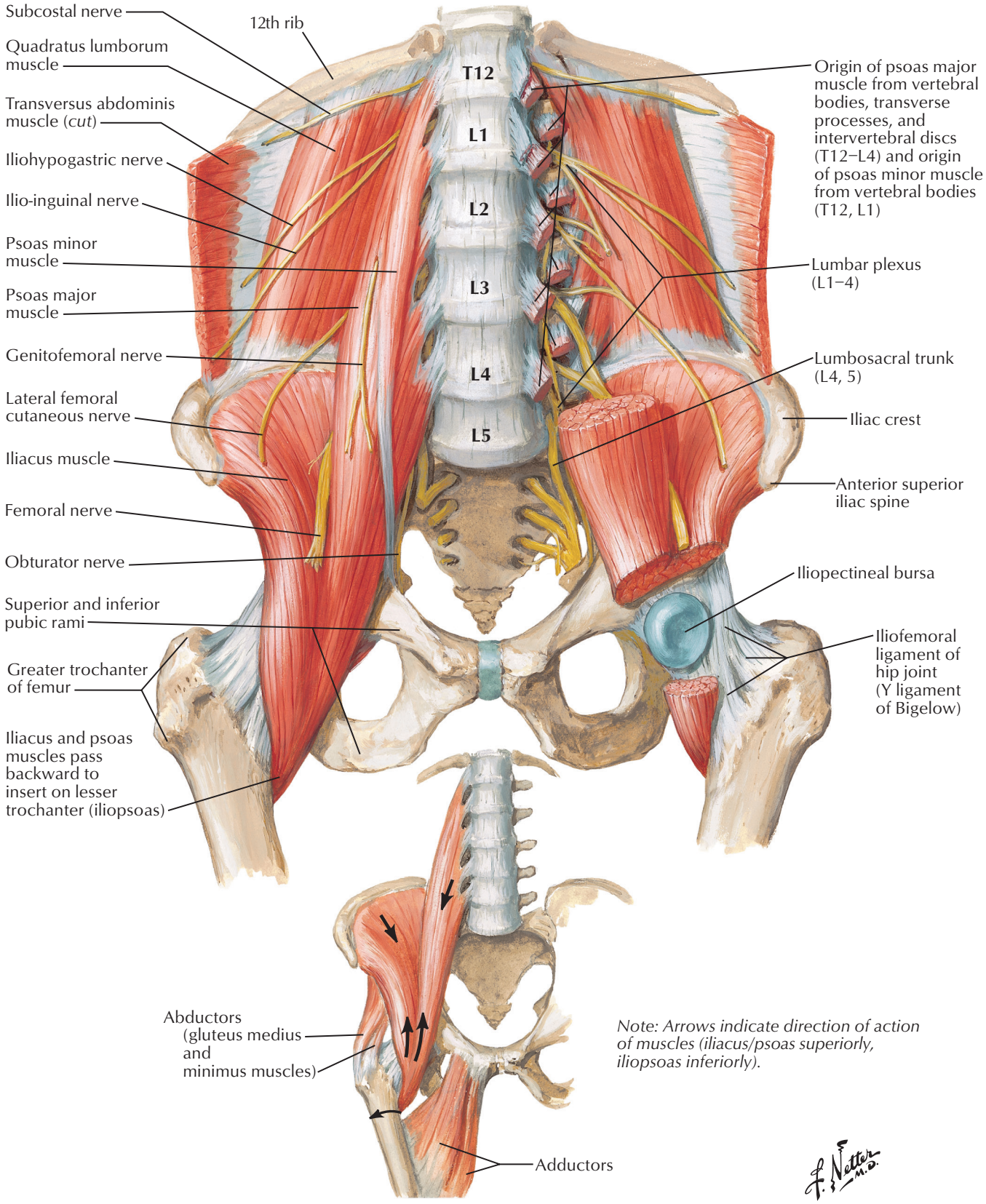
See also Plate 468

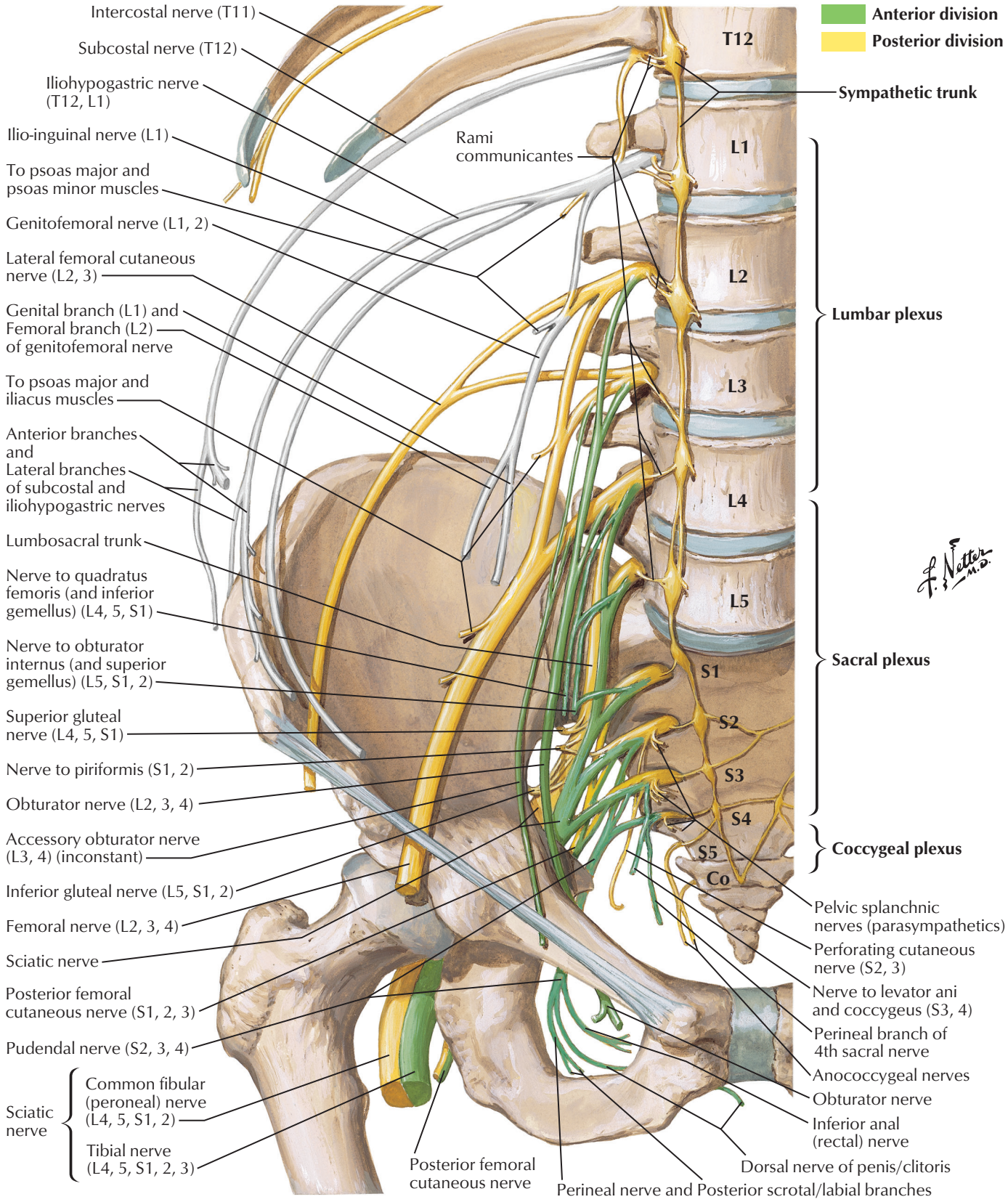



Superficial dissection
Deeper dissection
Iliac crest
Gluteal aponeurosis over Gluteus medius muscle
Gluteus minimus muscle
Gluteus maximus muscle
Piriformis muscle
Sciatic nerve
Sacrospinous ligament
Superior gemellus muscle
Obturator internus muscle
Inferior gemellus muscle
Sacrotuberous ligament
Quadratus femoris muscle
Ischial tuberosity
Semitendinosus muscle
Greater trochanter
Biceps femoris muscle (long head)
Adductor minimus part of Adductor magnus muscle
Semimembranosus muscle
Iliotibial tract
Gracilis muscle
Biceps femoris muscle
Short head
Long head
Semimembranosus muscle
Semitendinosus muscle
Popliteal vessels and tibial nerve
Common fibular (peroneal) nerve
Plantaris muscle
Gastrocnemius muscle
Medial head
Lateral head
Sartorius muscle
Popliteus muscle
Arch of Soleus muscle
Plantaris tendon (*cut*)
F. Netter M.D.

Psoas and Iliacus Muscles

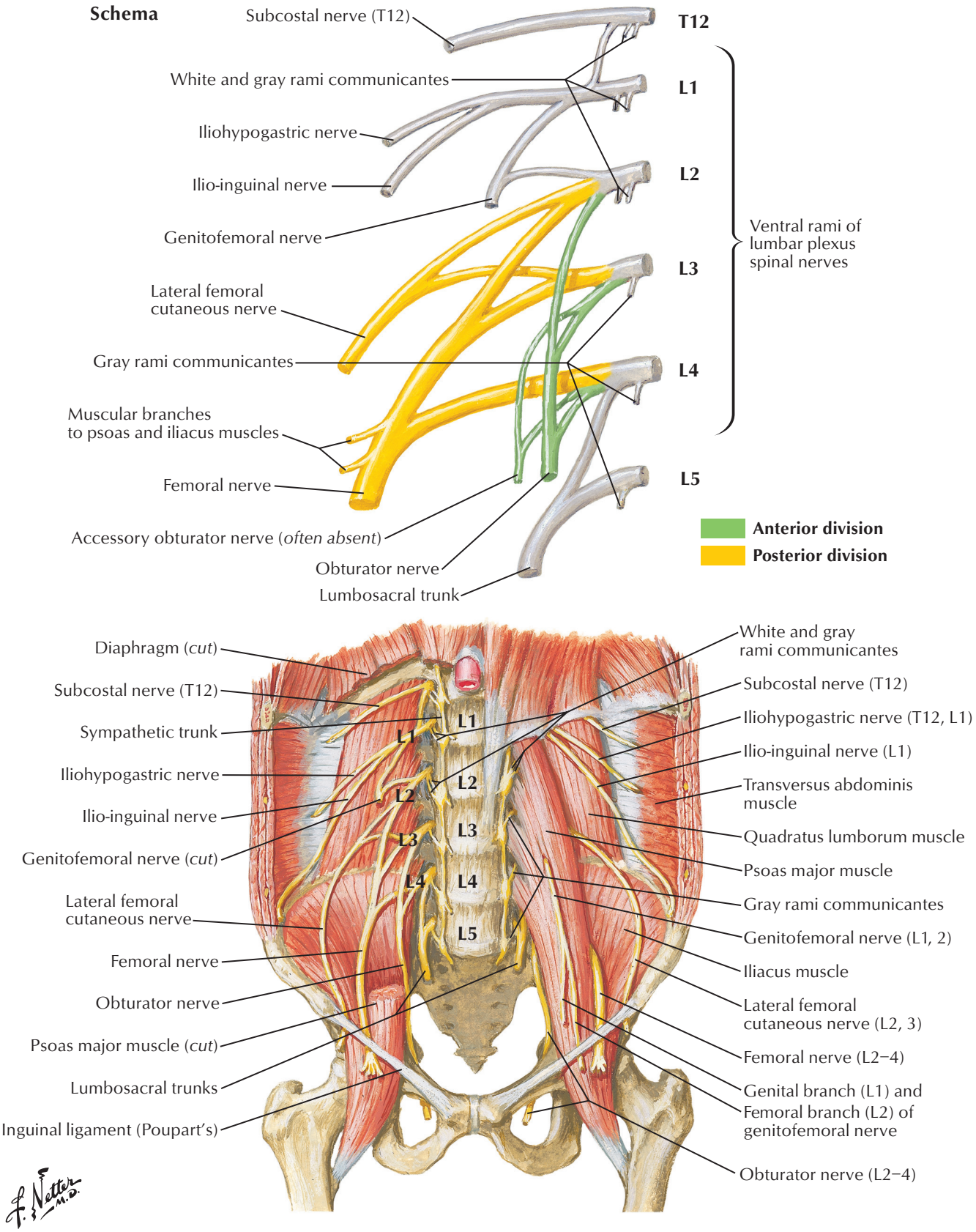
See also **Plates 253, 258, 262**

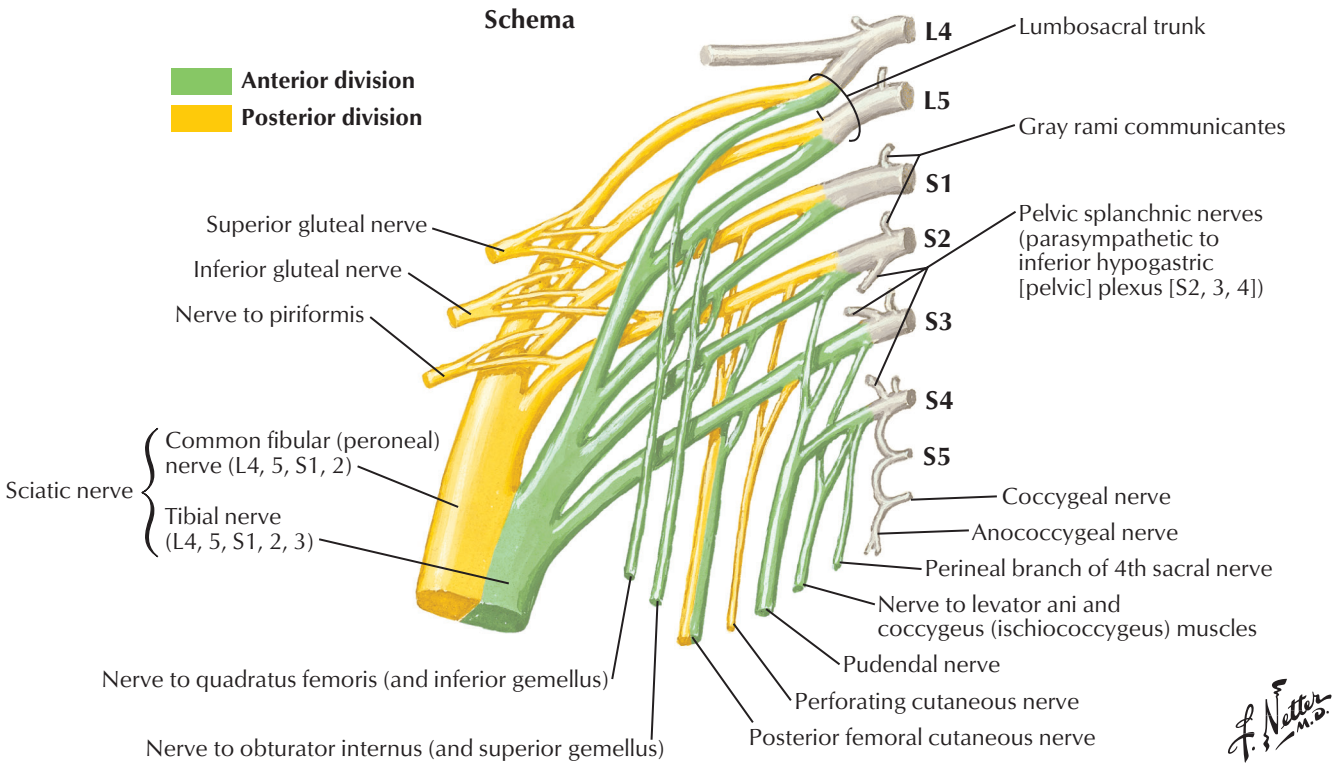


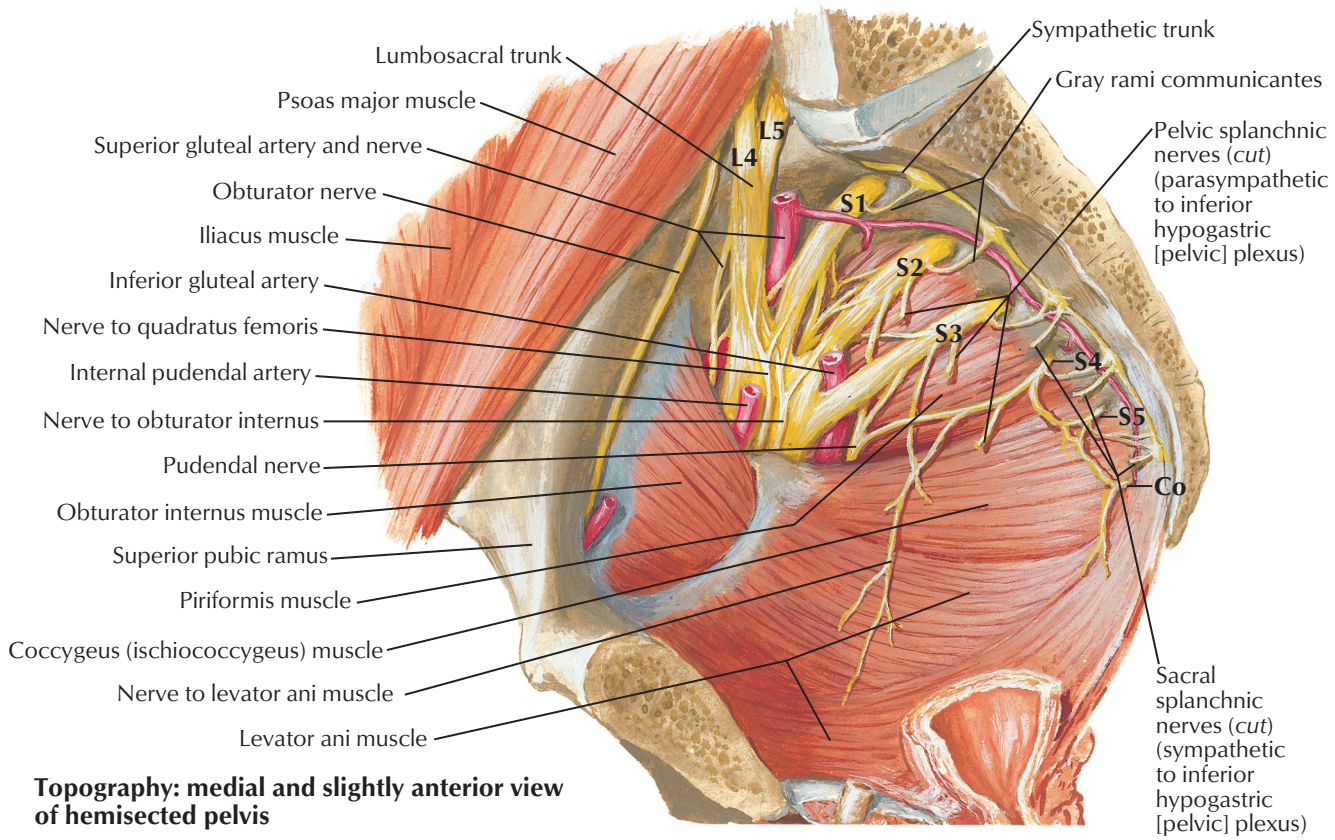

Intercostal nerve (T11)
Subcostal nerve (T12)
Iliohypogastric nerve (T12, L1)
Ilio-inguinal nerve (L1)
To psoas major and psoas minor muscles
Genitofemoral nerve (L1, 2)
Lateral femoral cutaneous nerve (L2, 3)
Genital branch (L1) and Femoral branch (L2) of genitofemoral nerve
To psoas major and iliacus muscles
Anterior branches and Lateral branches of subcostal and iliohypogastric nerves
Lumbosacral trunk
Nerve to quadratus femoris (and inferior gemellus) (L4, 5, S1)
Nerve to obturator internus (and superior gemellus) (L5, S1, 2)
Superior gluteal nerve (L4, 5, S1)
Nerve to piriformis (S1, 2)
Obturator nerve (L2, 3, 4)
Accessory obturator nerve (L3, 4) (inconstant)
Inferior gluteal nerve (L5, S1, 2)
Femoral nerve (L2, 3, 4)
Sciatic nerve
Posterior femoral cutaneous nerve (S1, 2, 3)
Pudendal nerve (S2, 3, 4)
Sciatic nerve
Common fibular (peroneal) nerve (L4, 5, S1, 2)
Tibial nerve (L4, 5, S1, 2, 3)
Rami communicantes
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
S5
Co
Anterior division
Posterior division
Sympathetic trunk
Lumbar plexus
Sacral plexus
Coccygeal plexus
Pelvic splanchnic nerves (parasympathetics)
Perforating cutaneous nerve (S2, 3)
Nerve to levator ani and coccygeus (S3, 4)
Perineal branch of 4th sacral nerve
Anococcygeal nerves
Obturator nerve
Inferior anal (rectal) nerve
Dorsal nerve of penis/clitoris
Posterior femoral cutaneous nerve
Perineal nerve and Posterior scrotal/labial branches

Lumbar Plexus

See also **Plate 262**



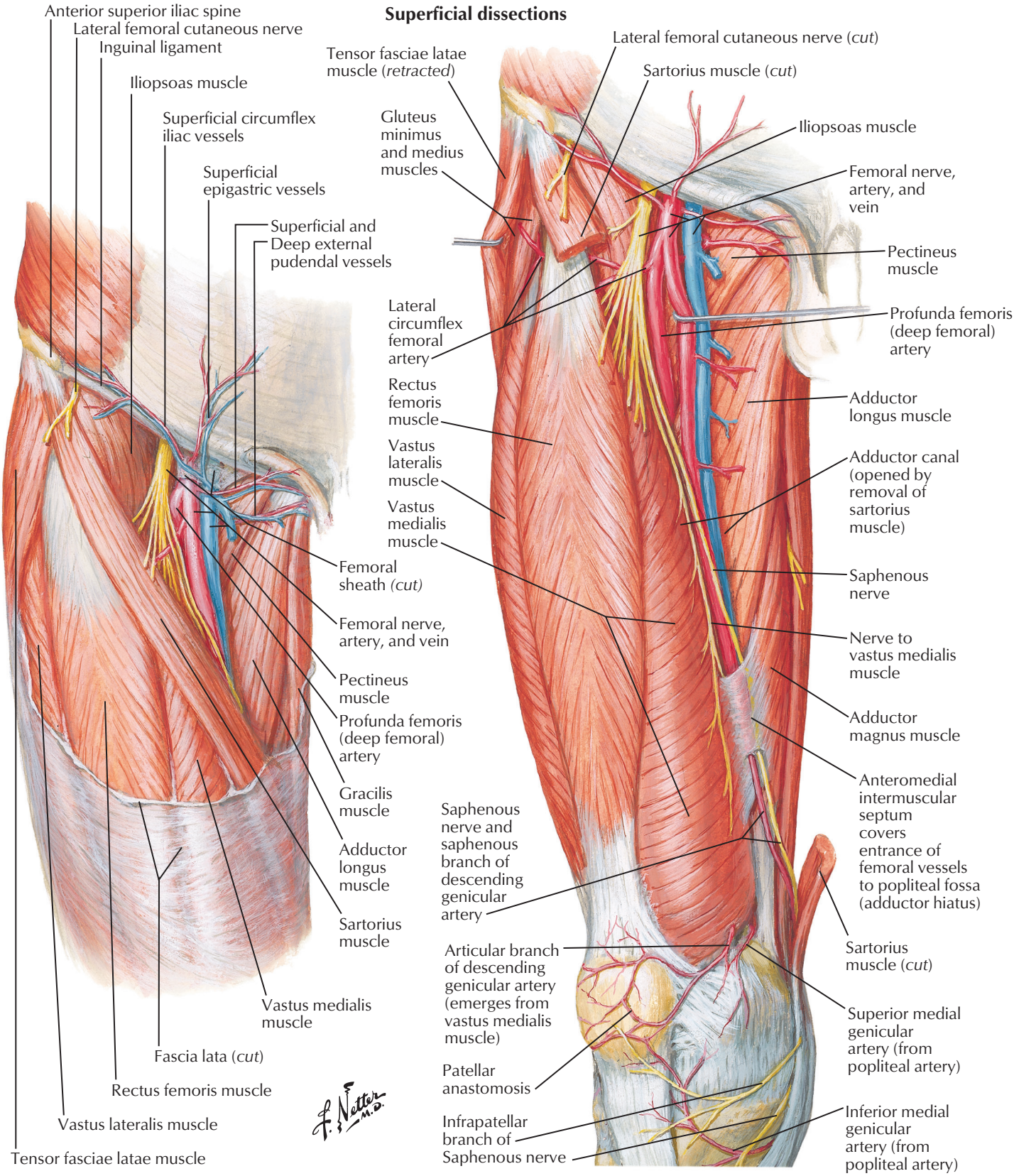




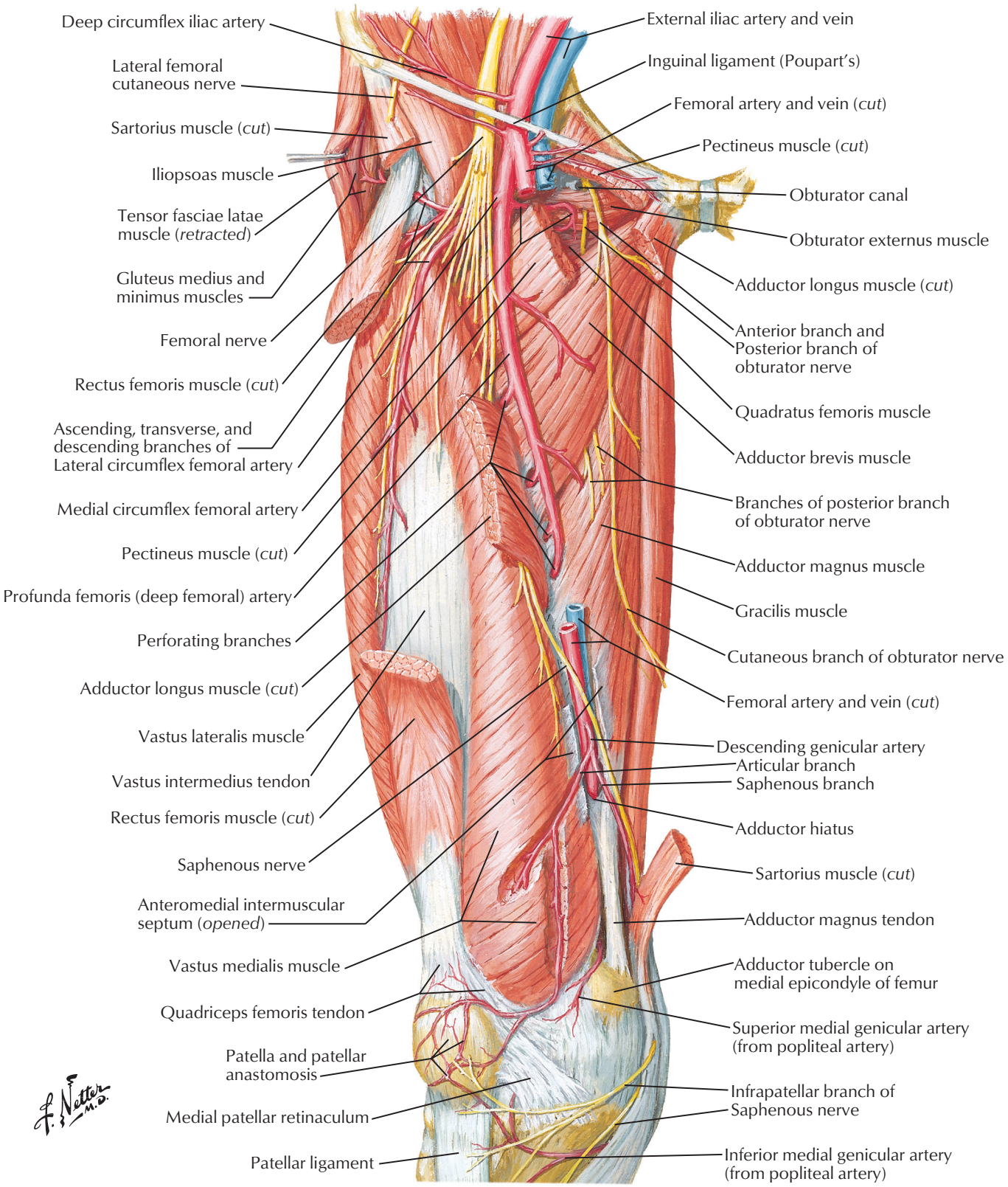
Topography: medial and slightly anterior view of hemisected pelvis

Arteries and Nerves of Thigh: Anterior Views

See also Plate 525



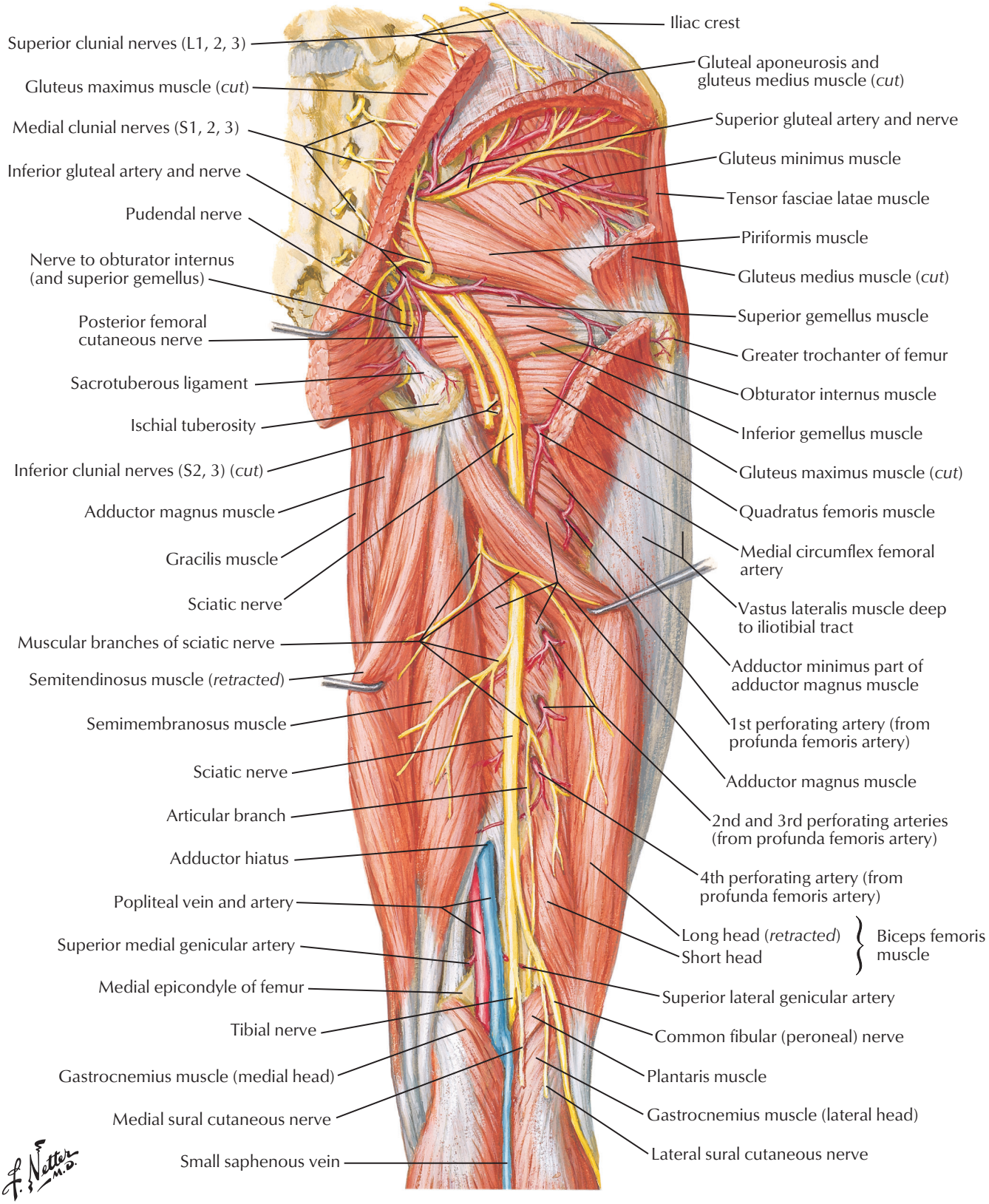
Deep dissection

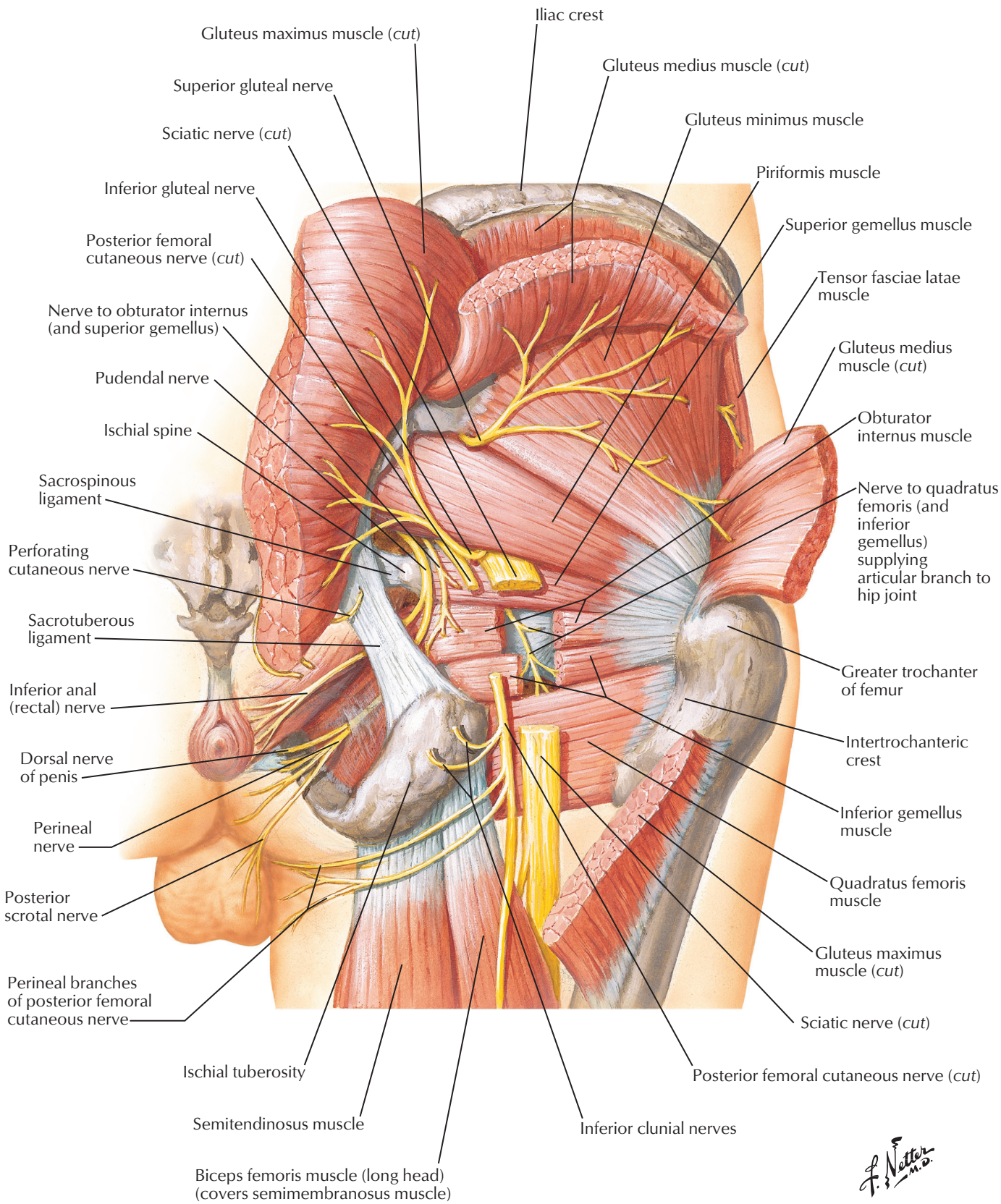


Arteries and Nerves of Thigh: Posterior View

See also Plate 527

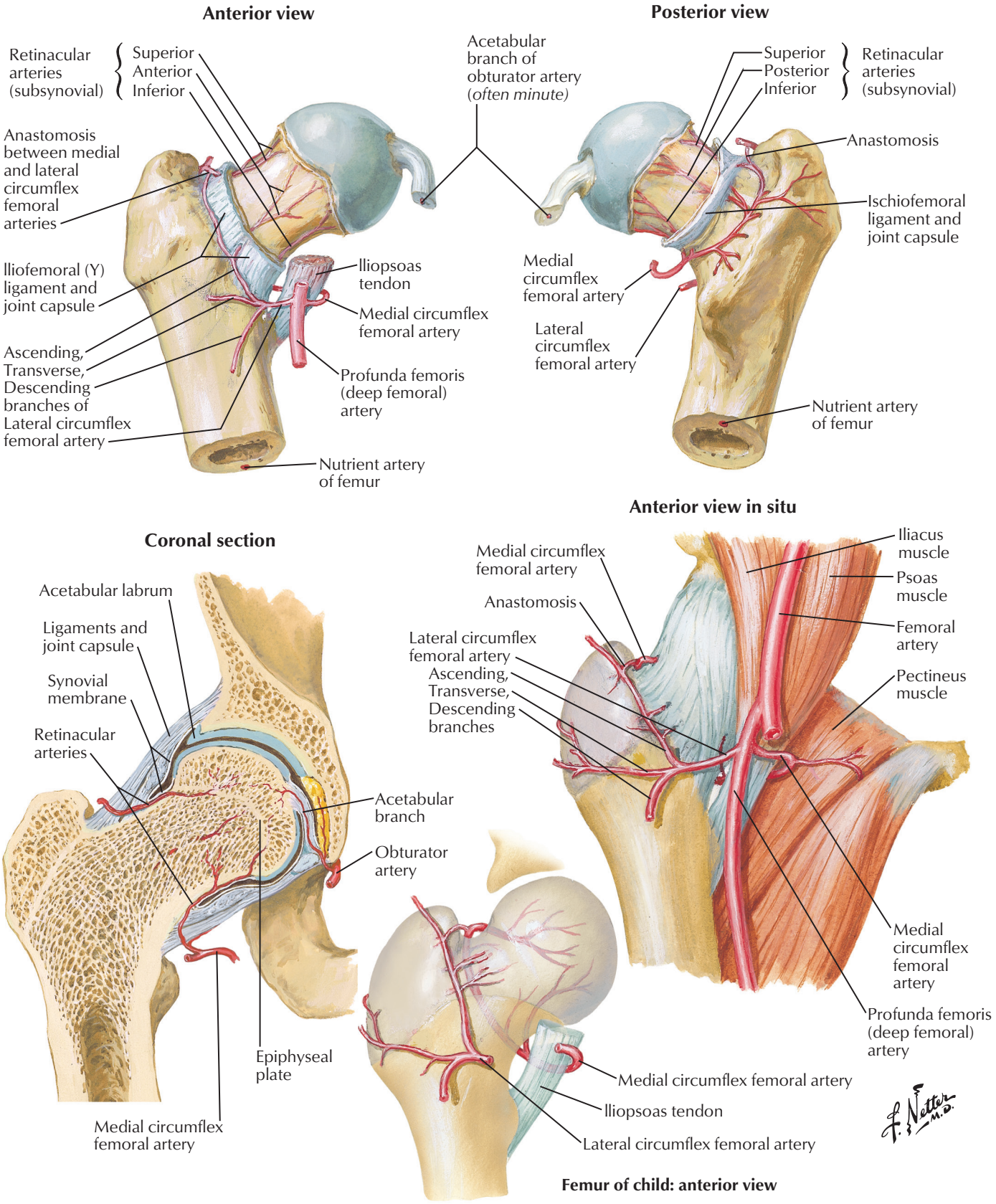
Deep dissection

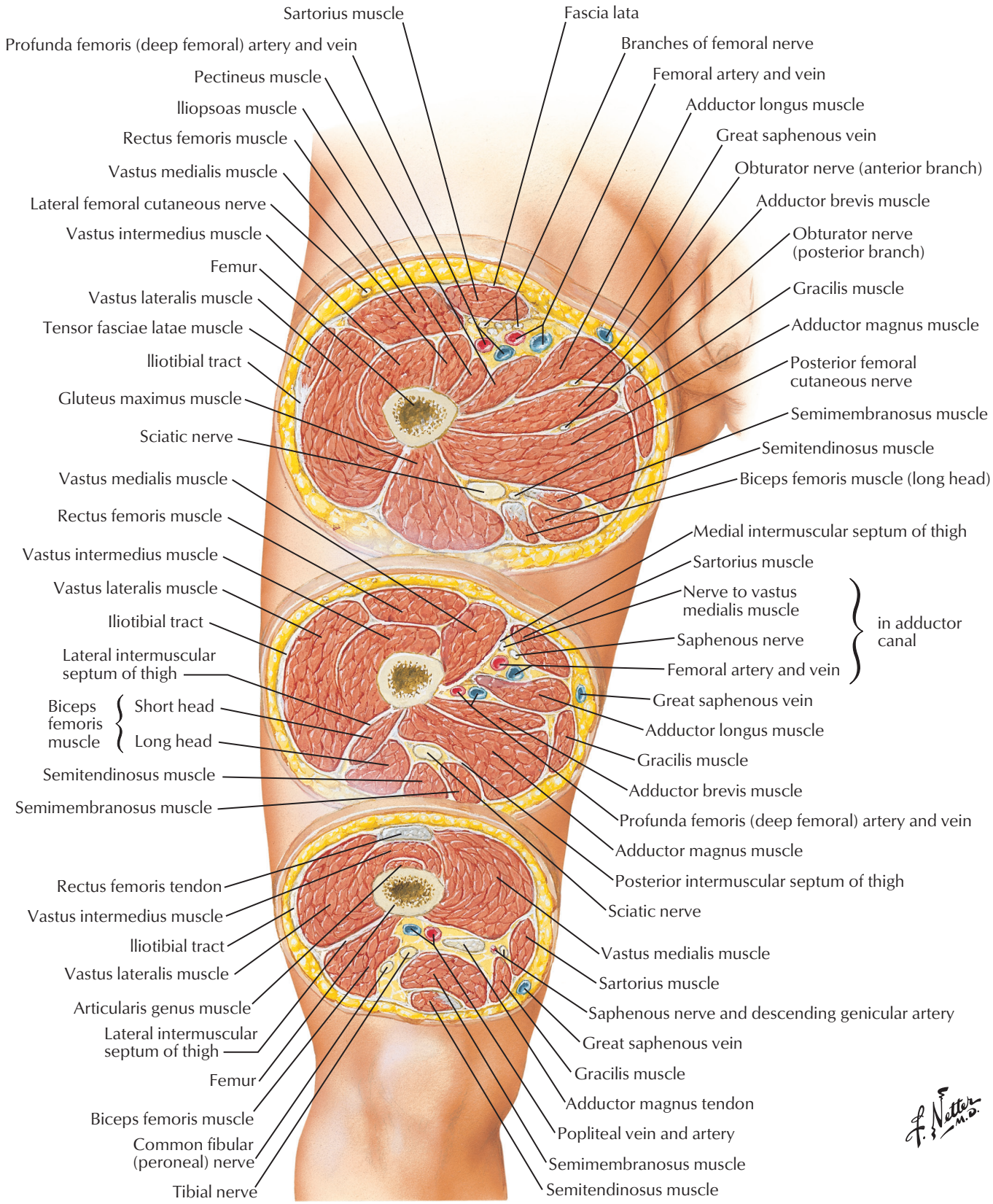



Iliac crest
Gluteus maximus muscle (*cut*)
Gluteus medius muscle (*cut*)
Superior gluteal nerve
Gluteus minimus muscle
Sciatic nerve (*cut*)
Piriformis muscle
Inferior gluteal nerve
Superior gemellus muscle
Posterior femoral cutaneous nerve (*cut*)
Tensor fasciae latae muscle
Nerve to obturator internus (and superior gemellus)
Gluteus medius muscle (*cut*)
Pudendal nerve
Obturator internus muscle
Ischial spine
Sacrospinous ligament
Nerve to quadratus femoris (and inferior gemellus) supplying articular branch to hip joint
Perforating cutaneous nerve
Sacrotuberous ligament
Greater trochanter of femur
Inferior anal (rectal) nerve
Intertrochanteric crest
Dorsal nerve of penis
Inferior gemellus muscle
Perineal nerve
Quadratus femoris muscle
Posterior scrotal nerve
Gluteus maximus muscle (*cut*)
Perineal branches of posterior femoral cutaneous nerve
Sciatic nerve (*cut*)
Ischial tuberosity
Posterior femoral cutaneous nerve (*cut*)
Semitendinosus muscle
Inferior clunial nerves
Biceps femoris muscle (long head) (covers semimembranosus muscle)

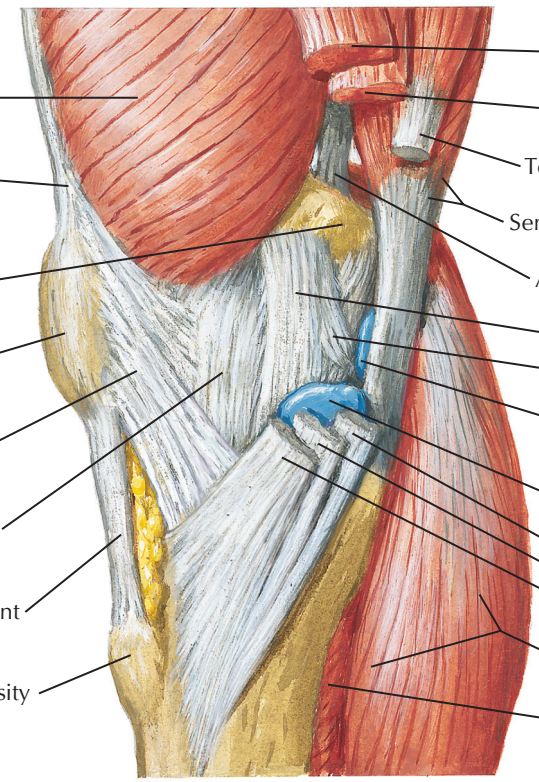
Arteries of Femoral Head and Neck

See also Plates 499, 530

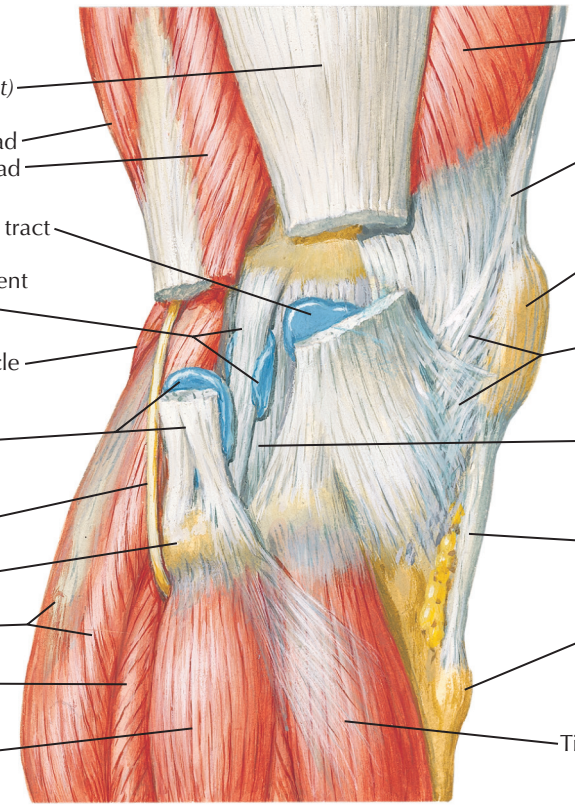



Sartorius muscle
Fascia lata
Profunda femoris (deep femoral) artery and vein
Branches of femoral nerve
Pectineus muscle
Femoral artery and vein
Iliopsoas muscle
Adductor longus muscle
Rectus femoris muscle
Great saphenous vein
Vastus medialis muscle
Obturator nerve (anterior branch)
Lateral femoral cutaneous nerve
Adductor brevis muscle
Vastus intermedius muscle
Obturator nerve (posterior branch)
Femur
Gracilis muscle
Vastus lateralis muscle
Adductor magnus muscle
Tensor fasciae latae muscle
Posterior femoral cutaneous nerve
Iliotibial tract
Semimembranosus muscle
Gluteus maximus muscle
Semitendinosus muscle
Sciatic nerve
Biceps femoris muscle (long head)
Vastus medialis muscle
Medial intermuscular septum of thigh
Rectus femoris muscle
Sartorius muscle
Vastus intermedius muscle
Nerve to vastus medialis muscle
Vastus lateralis muscle
Saphenous nerve
in adductor canal
Iliotibial tract
Femoral artery and vein
Lateral intermuscular septum of thigh
Great saphenous vein
Biceps femoris muscle
Short head
Adductor longus muscle
Long head
Gracilis muscle
Semitendinosus muscle
Adductor brevis muscle
Semimembranosus muscle
Profunda femoris (deep femoral) artery and vein
Adductor magnus muscle
Posterior intermuscular septum of thigh
Rectus femoris tendon
Sciatic nerve
Vastus intermedius muscle
Vastus medialis muscle
Iliotibial tract
Sartorius muscle
Vastus lateralis muscle
Saphenous nerve and descending genicular artery
Articularis genus muscle
Great saphenous vein
Lateral intermuscular septum of thigh
Gracilis muscle
Femur
Adductor magnus tendon
Biceps femoris muscle
Popliteal vein and artery
Common fibular (peroneal) nerve
Semimembranosus muscle
Tibial nerve
Semitendinosus muscle

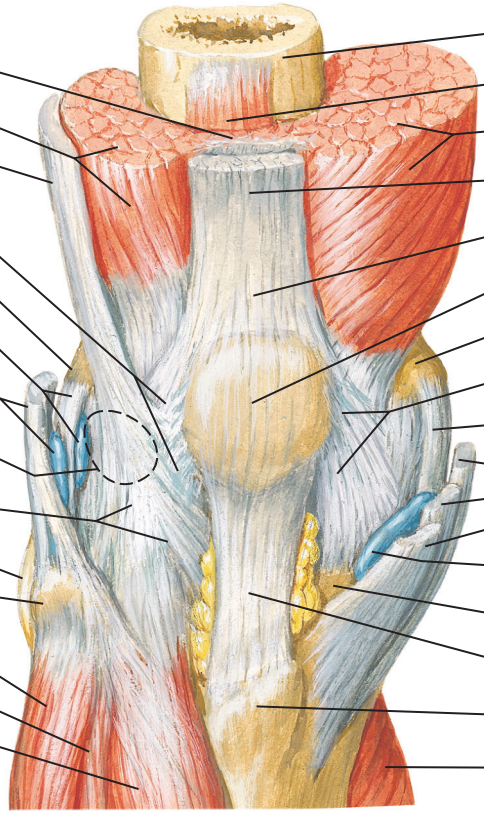
Medial view



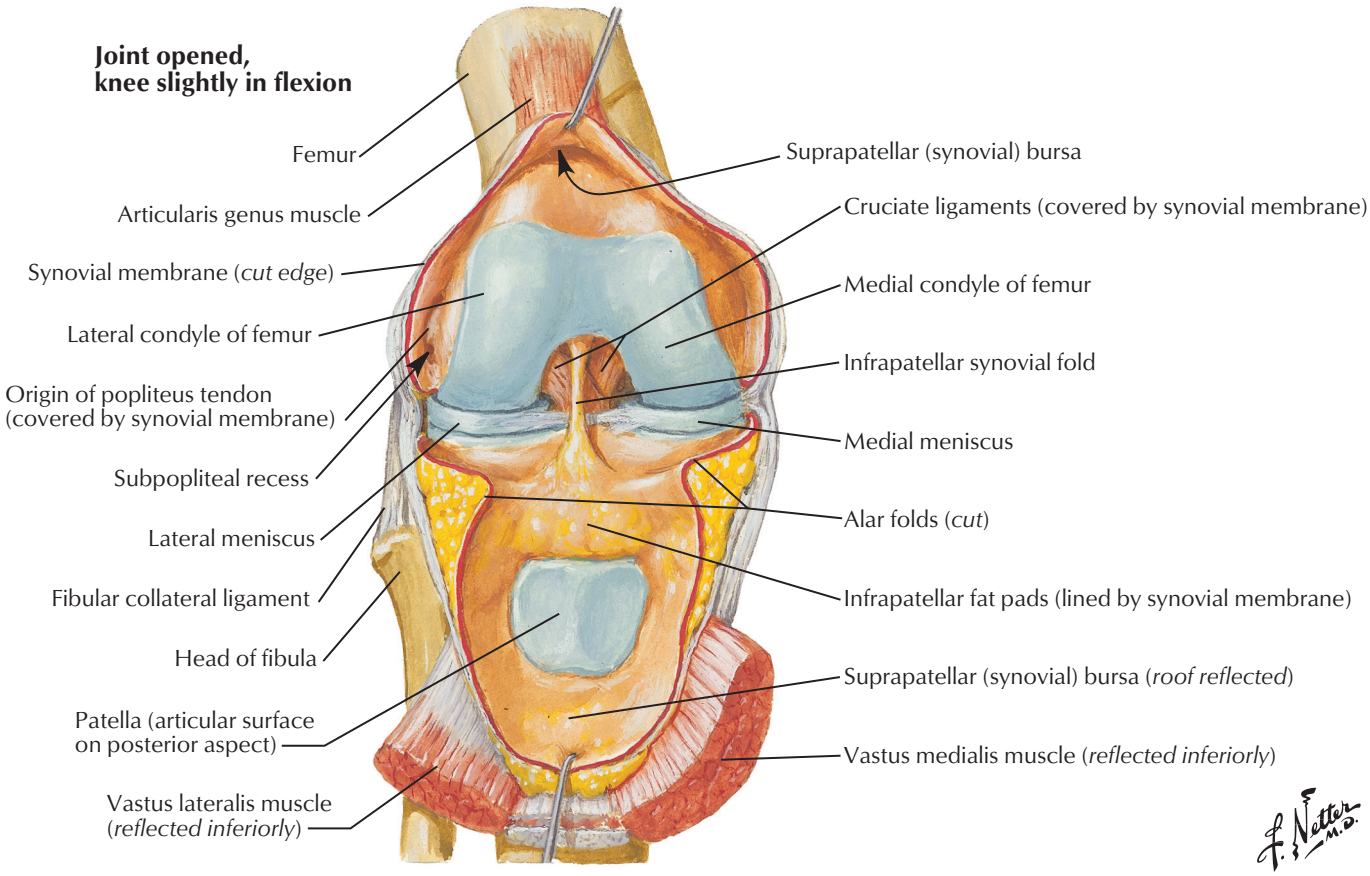
Lateral view



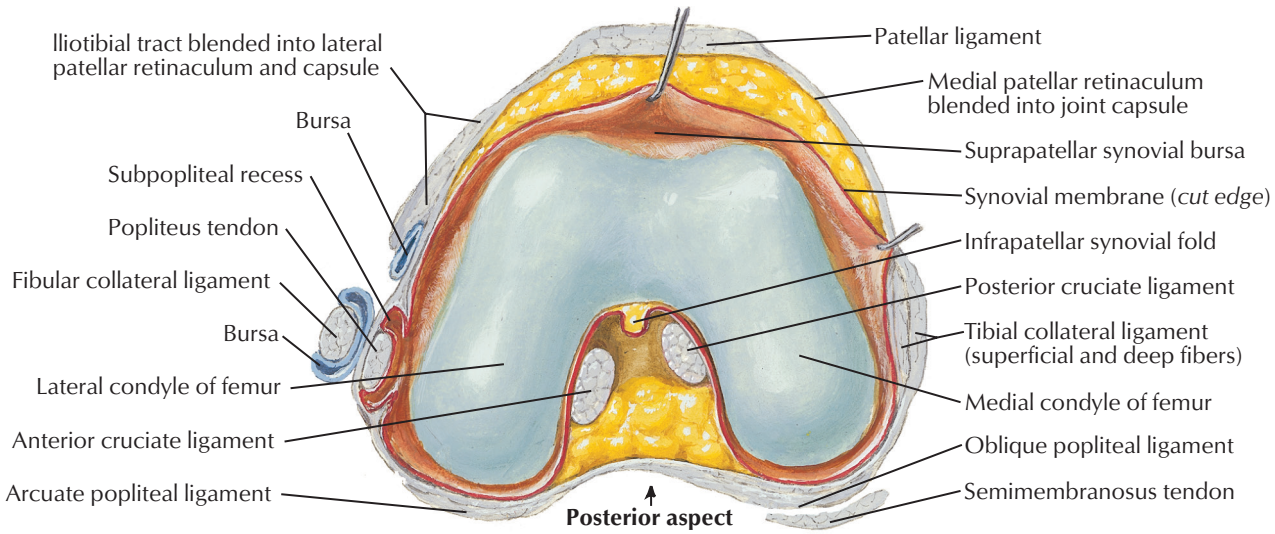
Right knee in extension



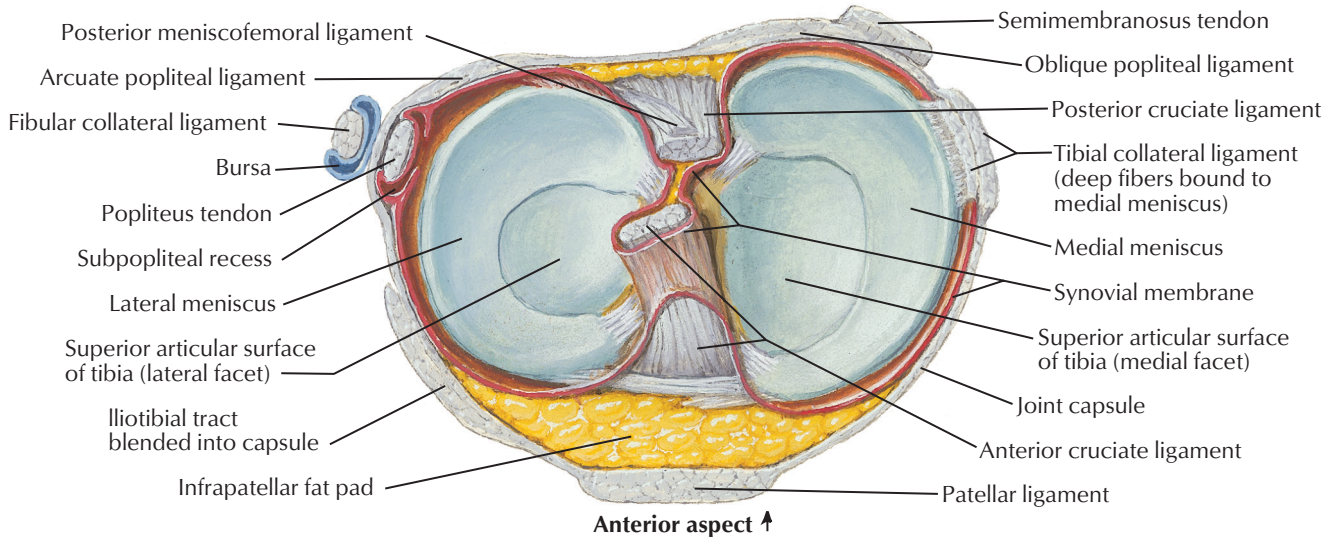
Joint opened, knee slightly in flexion



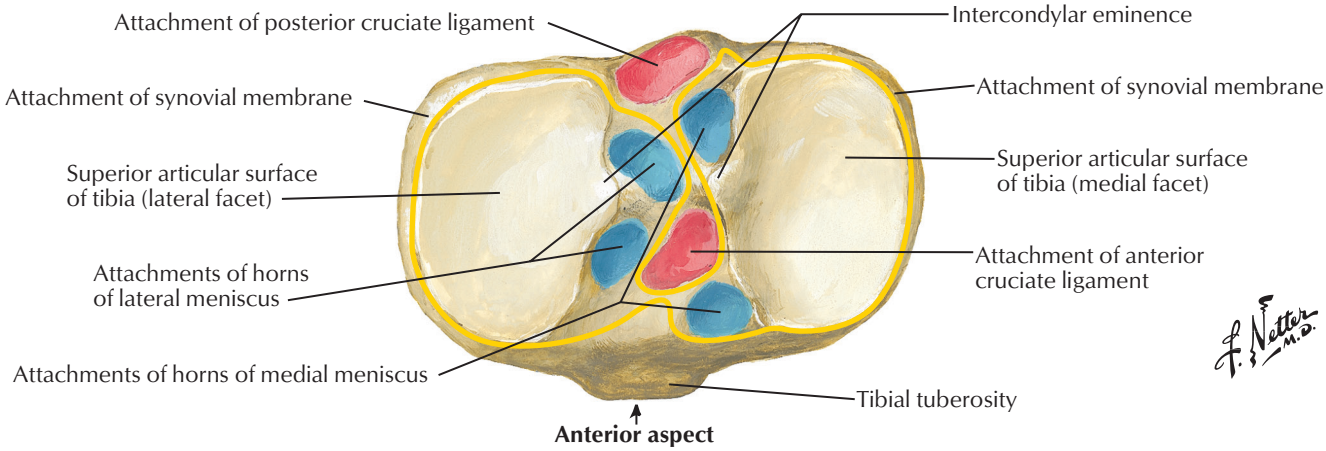
Inferior view



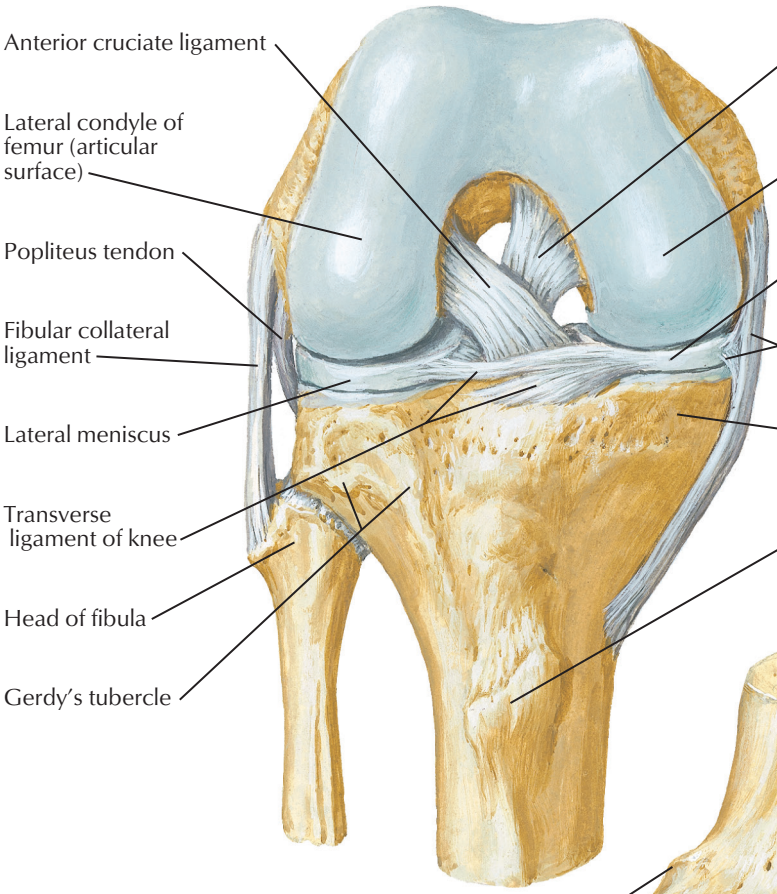
Superior view



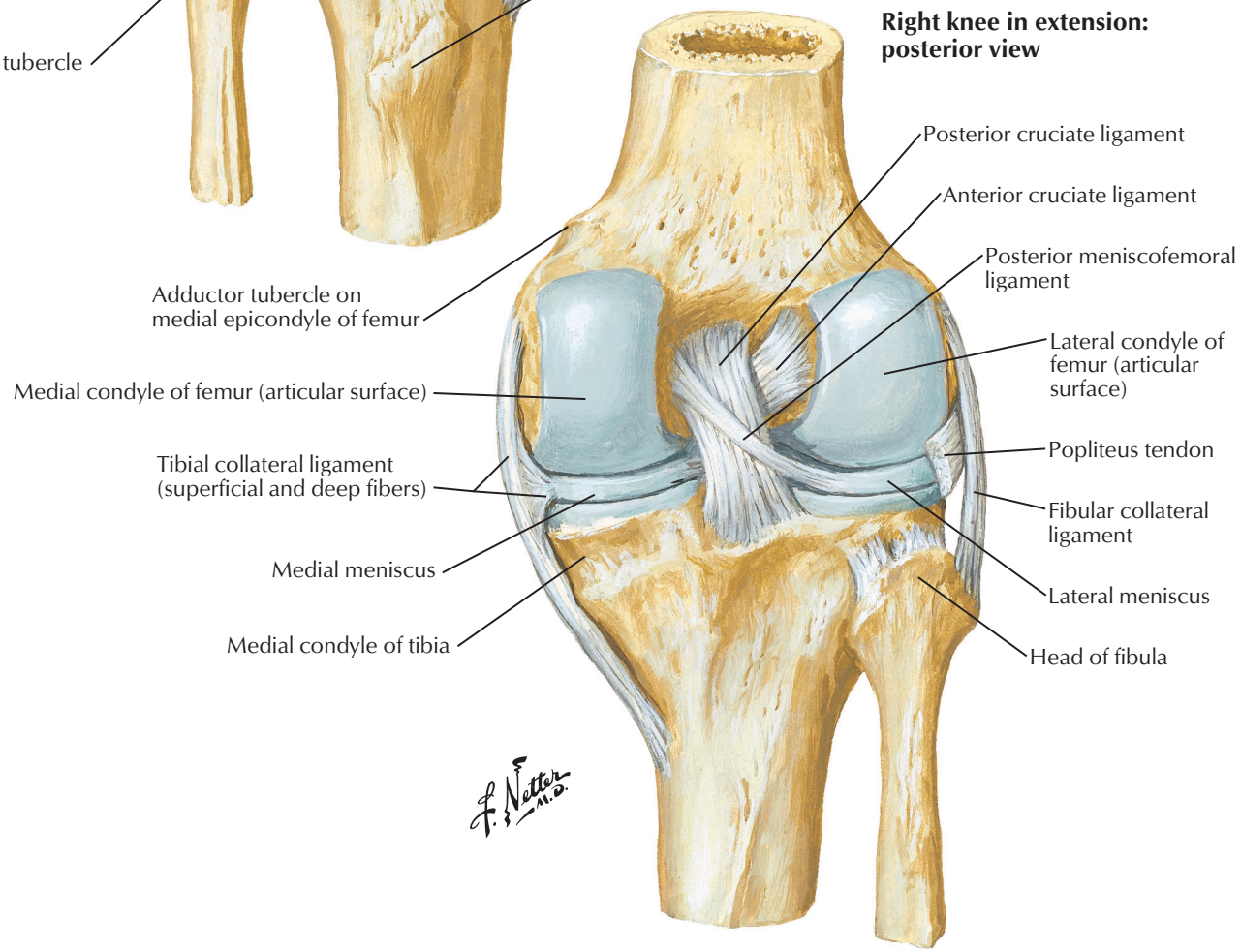
Superior view: ligaments and cartilage removed



Right knee in flexion: anterior view

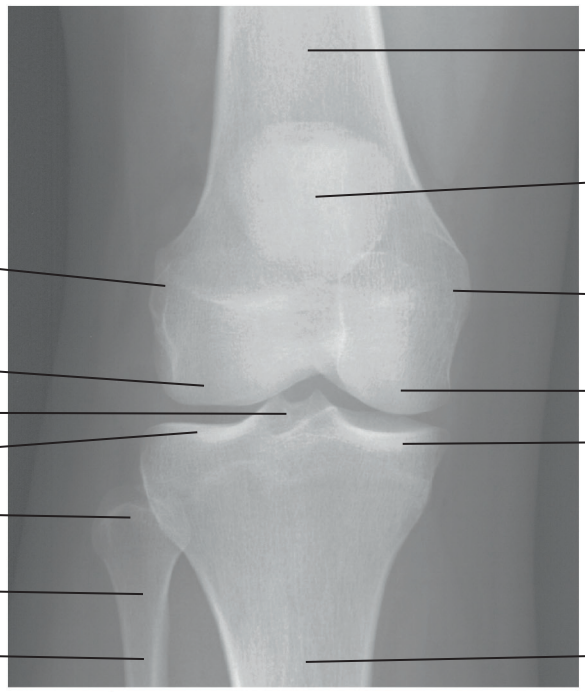


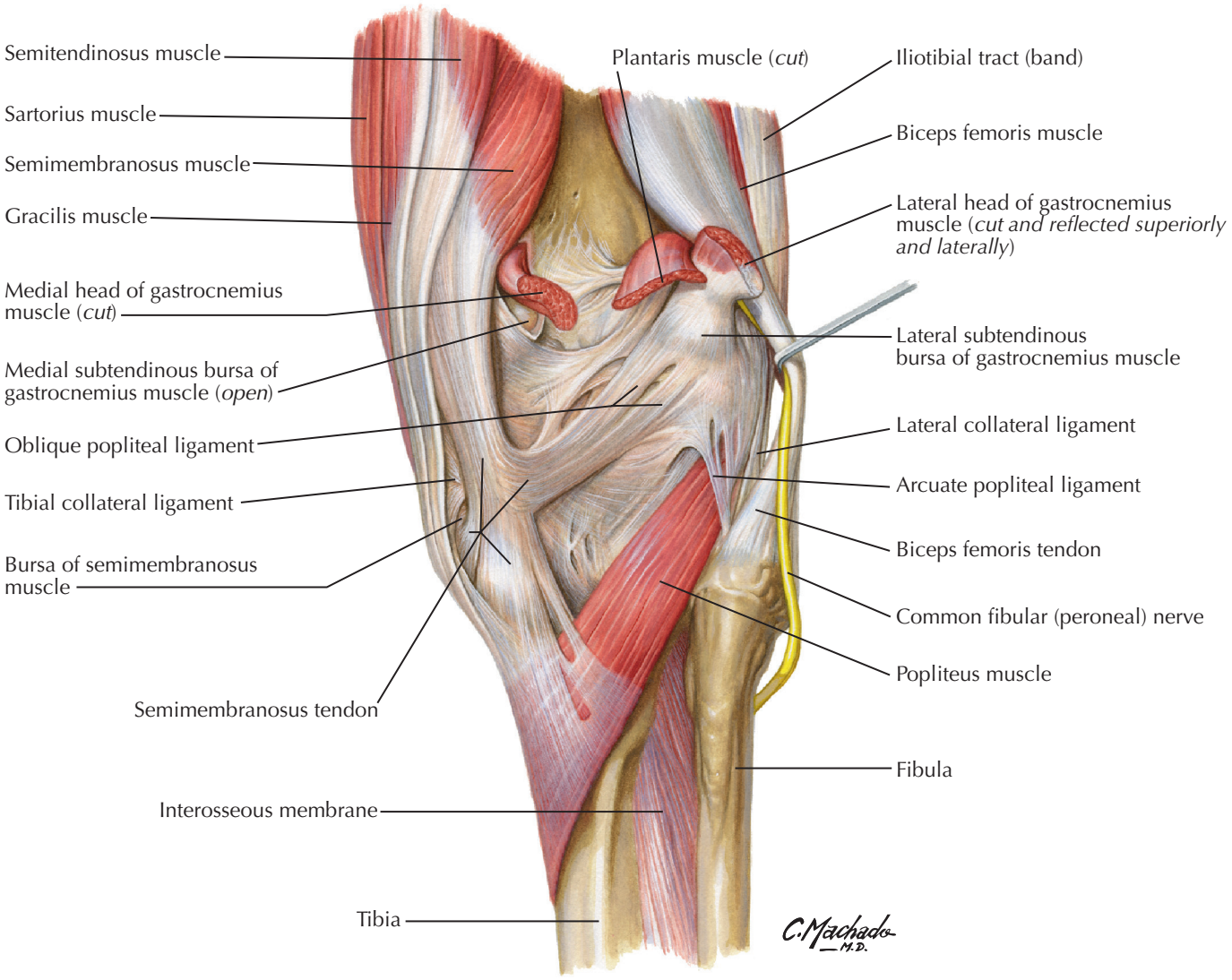
Right knee in extension: posterior view

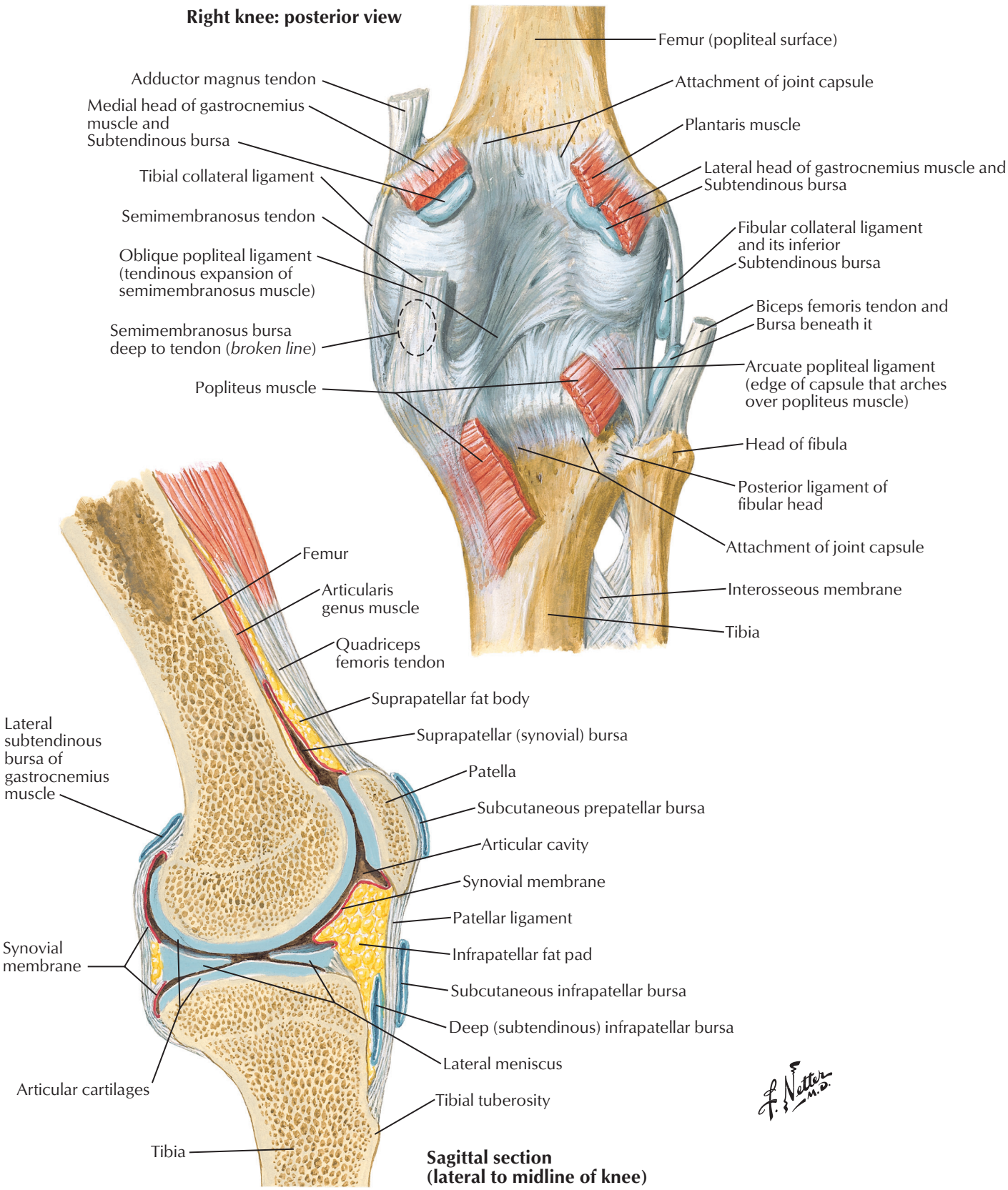


Knee: Anteroposterior Radiograph and Posterior View

See also Plate 494

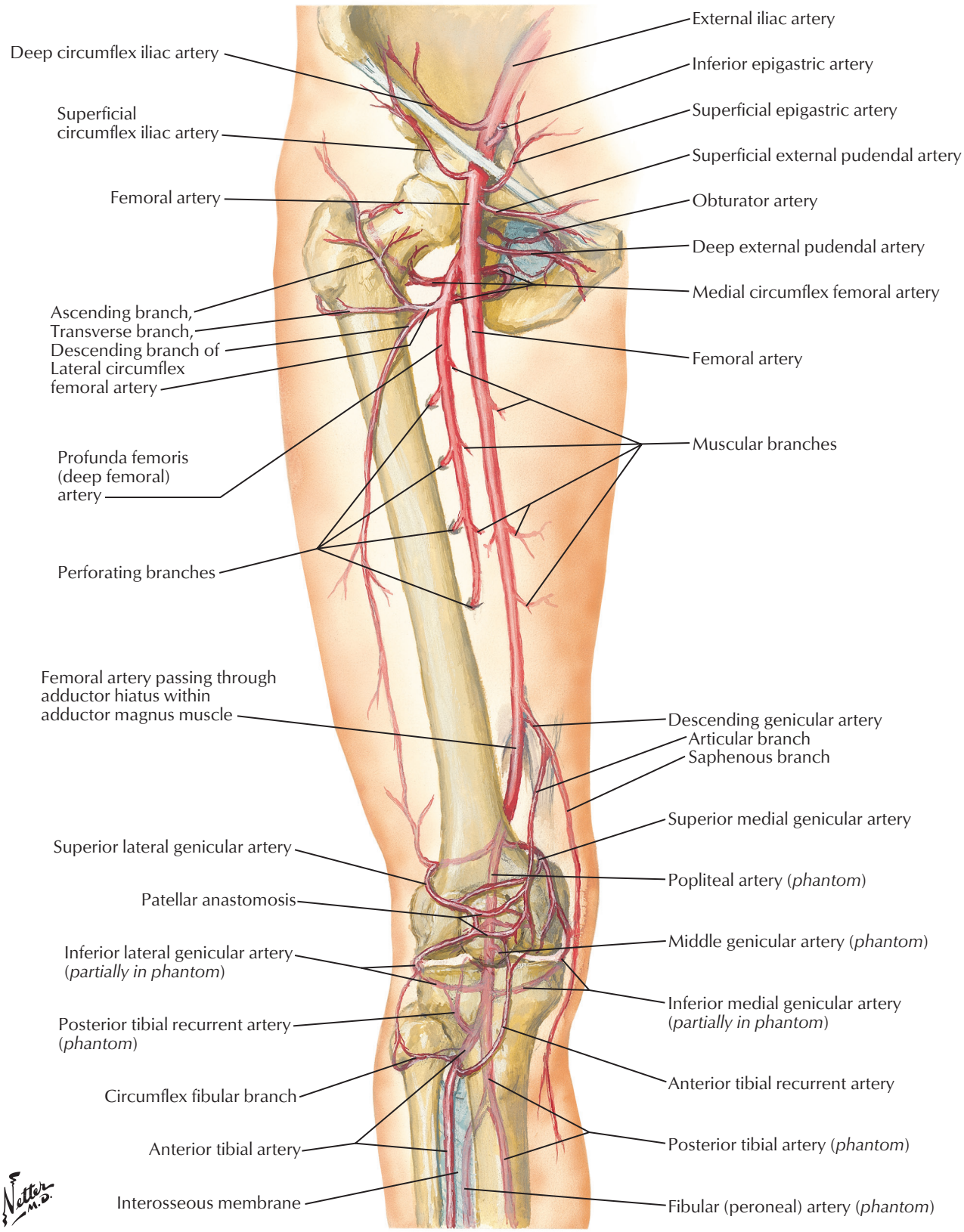


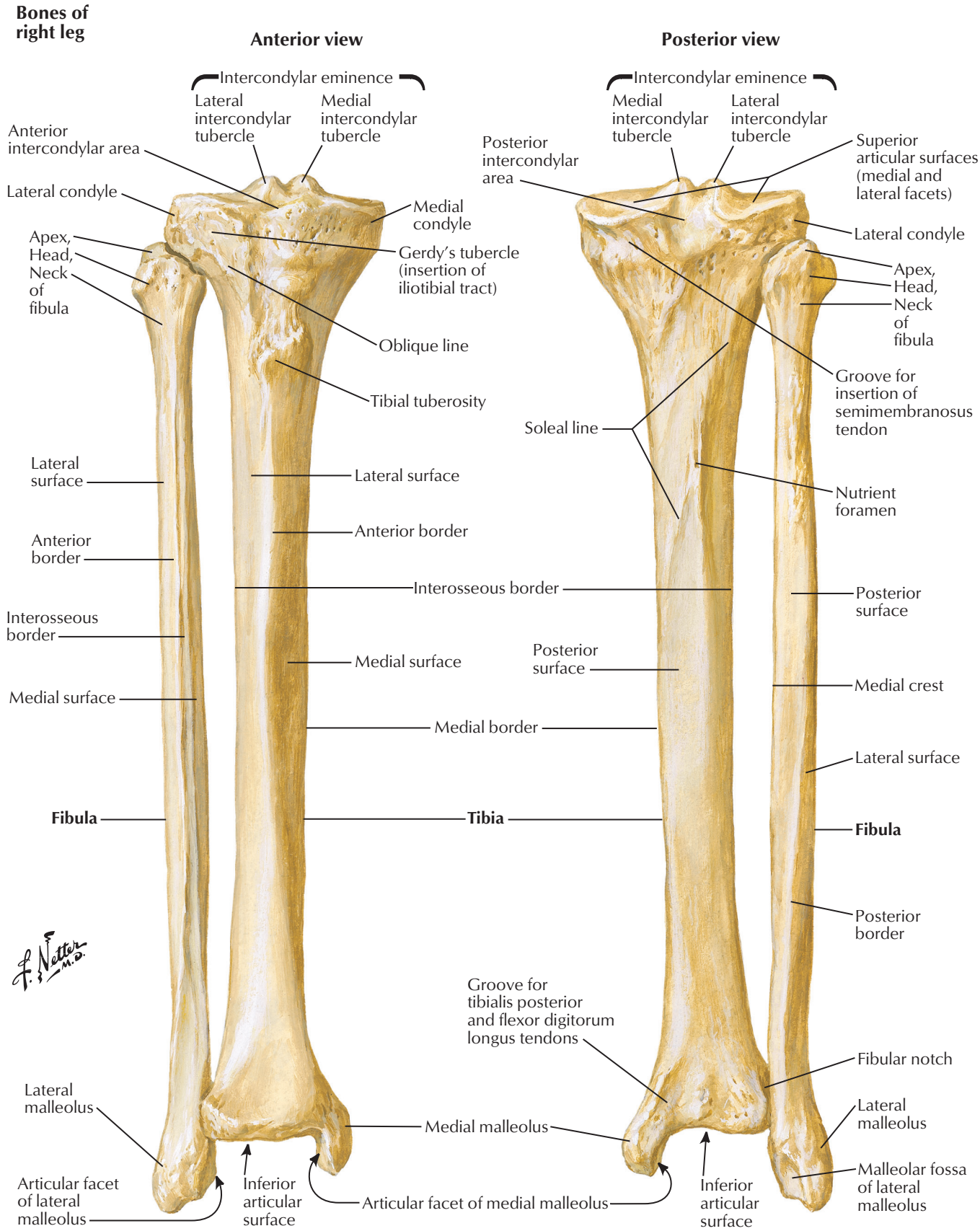



Right knee: posterior view
Femur (popliteal surface)
Attachment of joint capsule
Plantaris muscle
Lateral head of gastrocnemius muscle and Subtendinous bursa
Fibular collateral ligament and its inferior Subtendinous bursa
Biceps femoris tendon and Bursa beneath it
Arcuate popliteal ligament (edge of capsule that arches over popliteus muscle)
Head of fibula
Posterior ligament of fibular head
Attachment of joint capsule
Interosseous membrane
Tibia
Adductor magnus tendon
Medial head of gastrocnemius muscle and Subtendinous bursa
Tibial collateral ligament
Semimembranosus tendon
Oblique popliteal ligament (tendinous expansion of semimembranosus muscle)
Semimembranosus bursa deep to tendon (broken line)
Popliteus muscle
Femur
Articularis genus muscle
Quadriceps femoris tendon
Suprapatellar fat body
Suprapatellar (synovial) bursa
Patella
Subcutaneous prepatellar bursa
Articular cavity
Synovial membrane
Patellar ligament
Infrapatellar fat pad
Subcutaneous infrapatellar bursa
Deep (subtendinous) infrapatellar bursa
Lateral meniscus
Tibial tuberosity
Tibia
Lateral subtendinous bursa of gastrocnemius muscle
Synovial membrane
Articular cartilages
Sagittal section (lateral to midline of knee)

Arteries of Thigh and Knee: Schema

See also Plates 491, 508, 509, 518

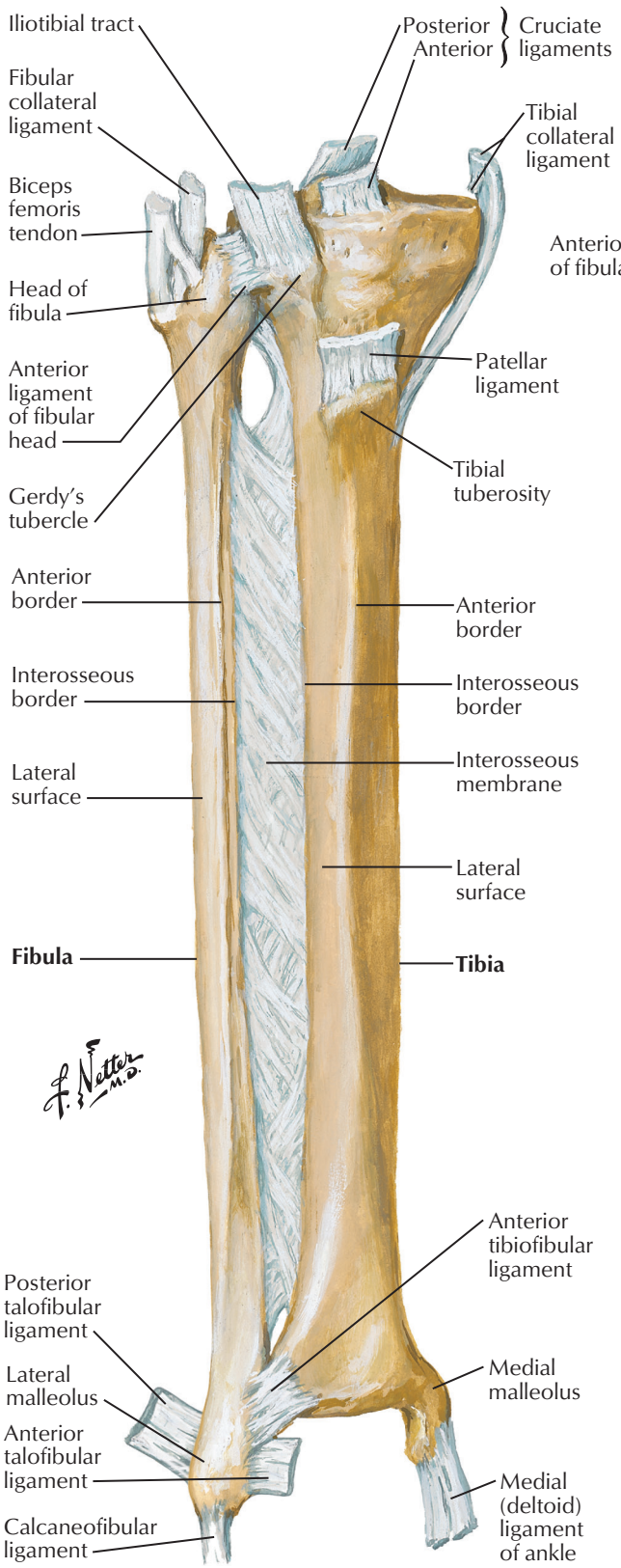



Bones of right leg
Anterior view
Posterior view
Intercondylar eminence
Lateral intercondylar tubercle
Medial intercondylar tubercle
Anterior intercondylar area
Lateral condyle
Medial condyle
Apex, Head, Neck of fibula
Gerdy's tubercle (insertion of iliotibial tract)
Oblique line
Tibial tuberosity
Lateral surface
Anterior border
Interosseous border
Medial surface
Medial border
Fibula
Tibia
Lateral malleolus
Medial malleolus
Articular facet of lateral malleolus
Inferior articular surface
Articular facet of medial malleolus
Posterior intercondylar area
Superior articular surfaces (medial and lateral facets)
Groove for insertion of semimembranosus tendon
Soleal line
Nutrient foramen
Posterior surface
Medial crest
Posterior border
Groove for tibialis posterior and flexor digitorum longus tendons
Fibular notch
Malleolar fossa of lateral malleolus

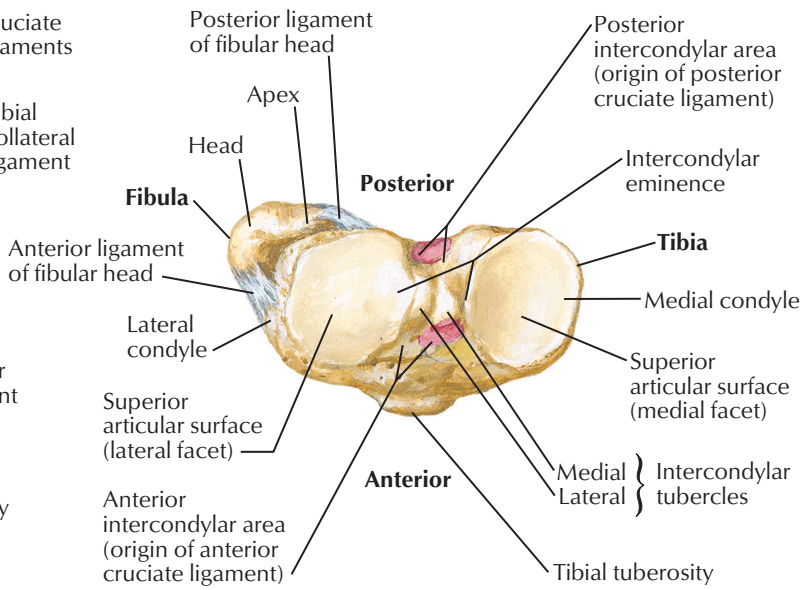
Tibia and Fibula (continued)

See also Plate 495

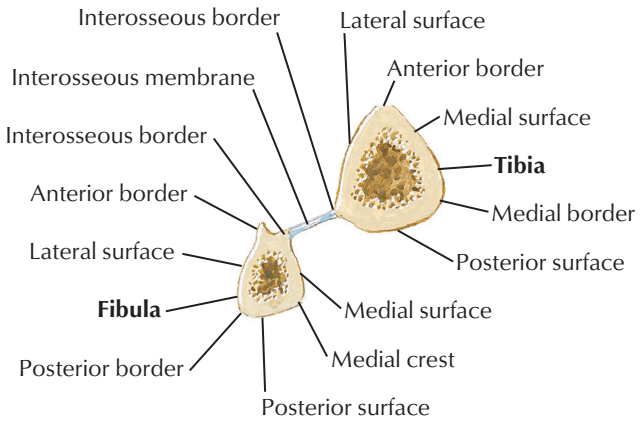
Anterior view with ligament attachments



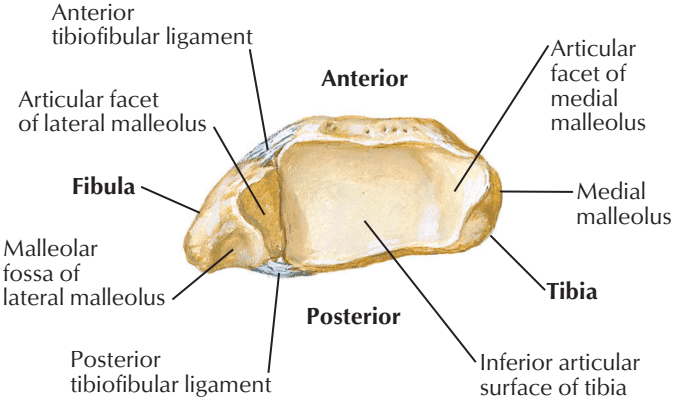
Superior view

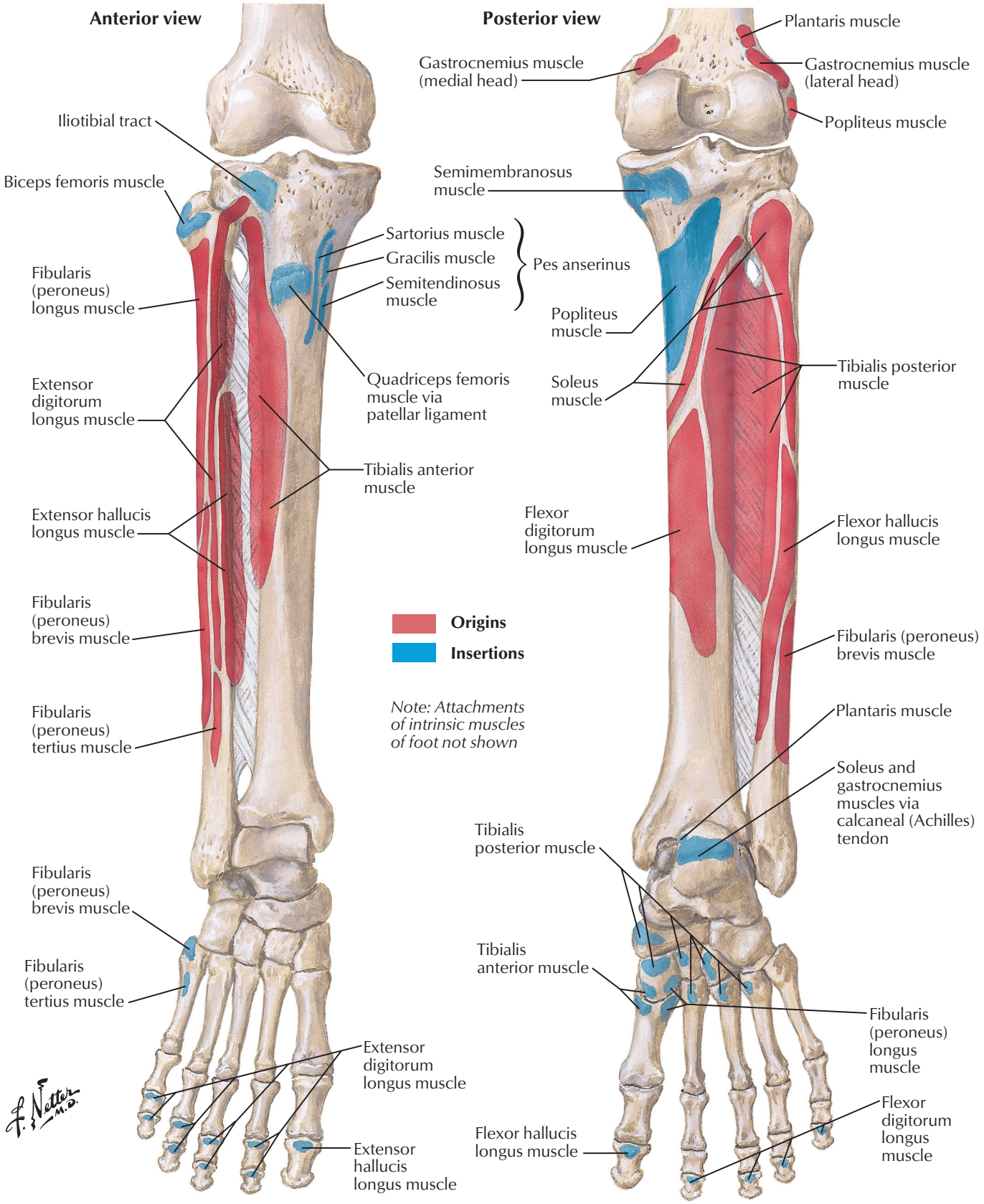


Cross section



Inferior view

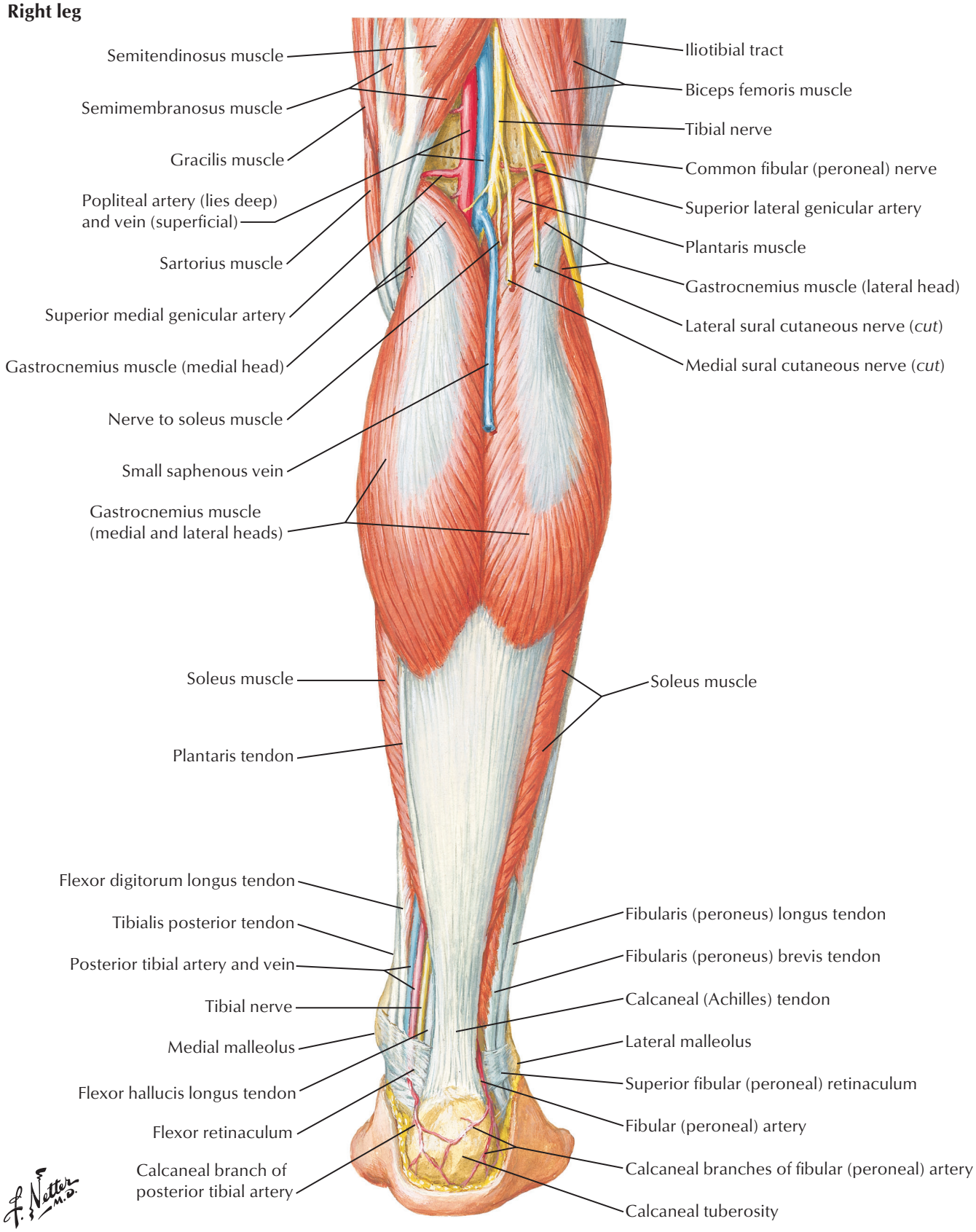



Anterior view
Posterior view
Iliotibial tract
Biceps femoris muscle
Fibularis (peroneus) longus muscle
Extensor digitorum longus muscle
Extensor hallucis longus muscle
Fibularis (peroneus) brevis muscle
Fibularis (peroneus) tertius muscle
Fibularis (peroneus) brevis muscle
Fibularis (peroneus) tertius muscle
Sartorius muscle
Gracilis muscle
Semitendinosus muscle
Pes anserinus
Quadriceps femoris muscle via patellar ligament
Tibialis anterior muscle
Extensor digitorum longus muscle
Extensor hallucis longus muscle
Origins
Insertions
Note: Attachments of intrinsic muscles of foot not shown
Gastrocnemius muscle (medial head)
Plantaris muscle
Gastrocnemius muscle (lateral head)
Popliteus muscle
Semimembranosus muscle
Popliteus muscle
Soleus muscle
Tibialis posterior muscle
Flexor digitorum longus muscle
Flexor hallucis longus muscle
Fibularis (peroneus) brevis muscle
Plantaris muscle
Soleus and gastrocnemius muscles via calcaneal (Achilles) tendon
Tibialis posterior muscle
Tibialis anterior muscle
Fibularis (peroneus) longus muscle
Flexor digitorum longus muscle
Flexor hallucis longus muscle

Muscles of Leg (Superficial Dissection): Posterior View

See also Plate 528

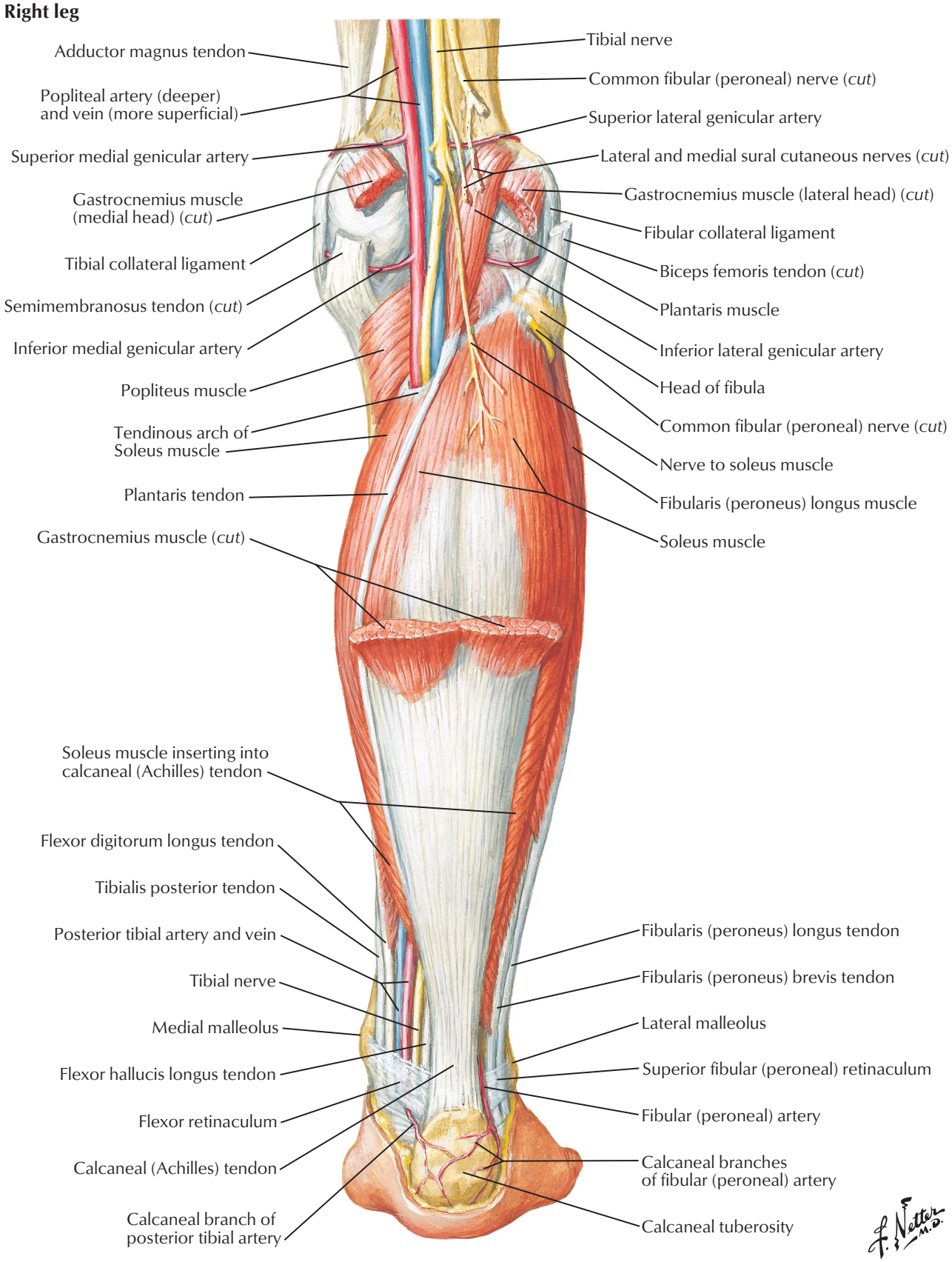
Right leg



Muscles of Leg (Intermediate Dissection): Posterior View

See also Plate 528

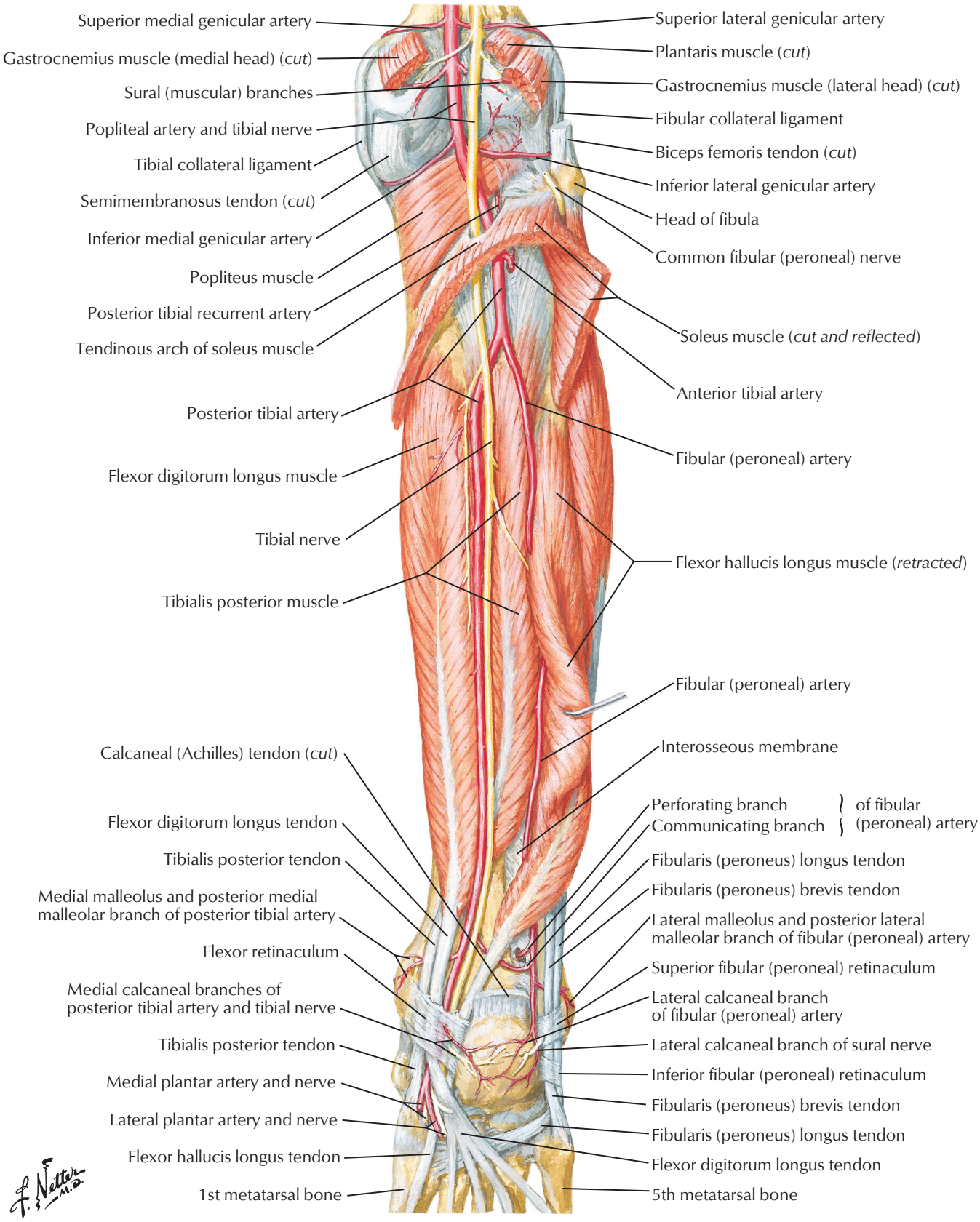
Right leg

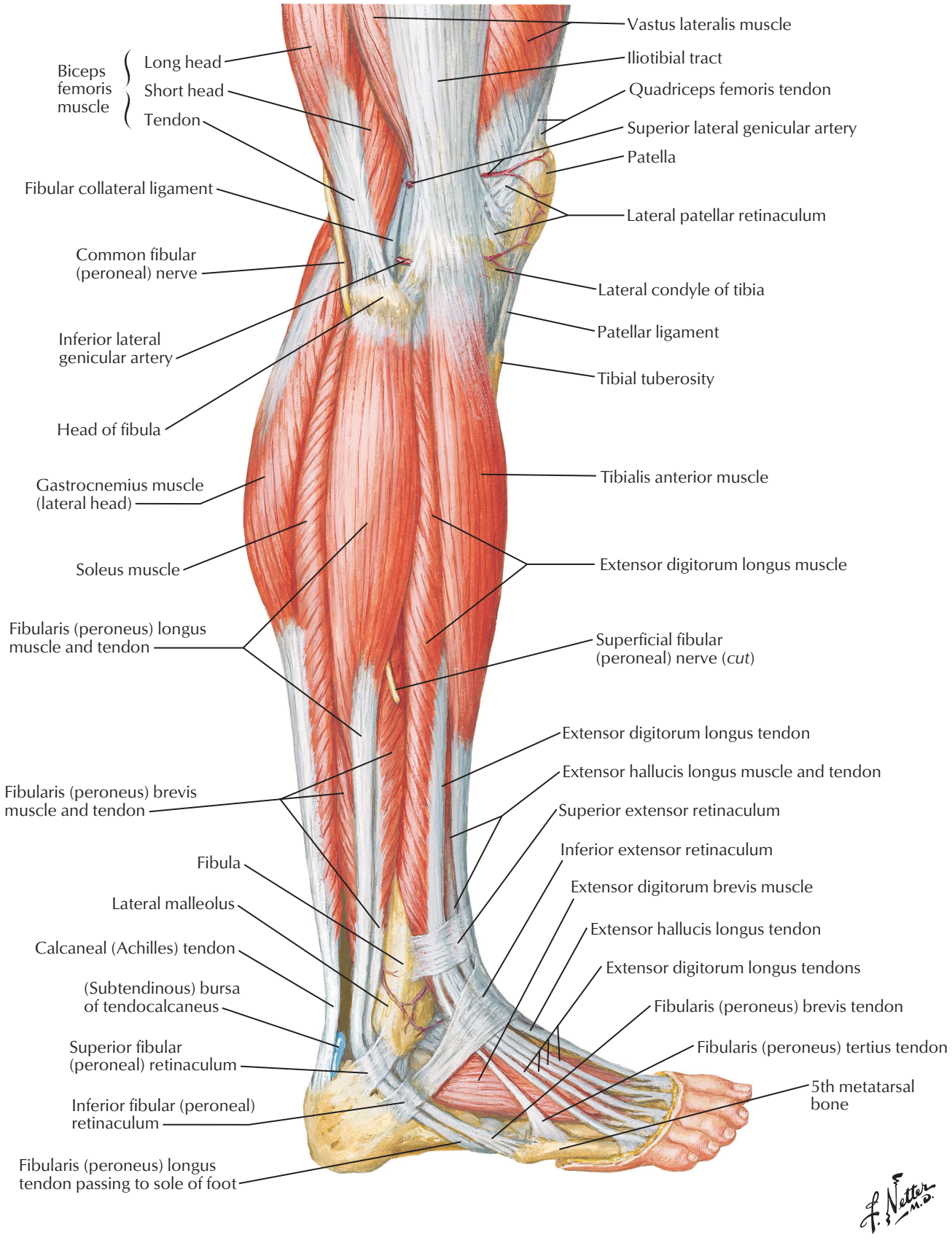


Muscles of Leg (Deep Dissection): Posterior View

See also Plate 528

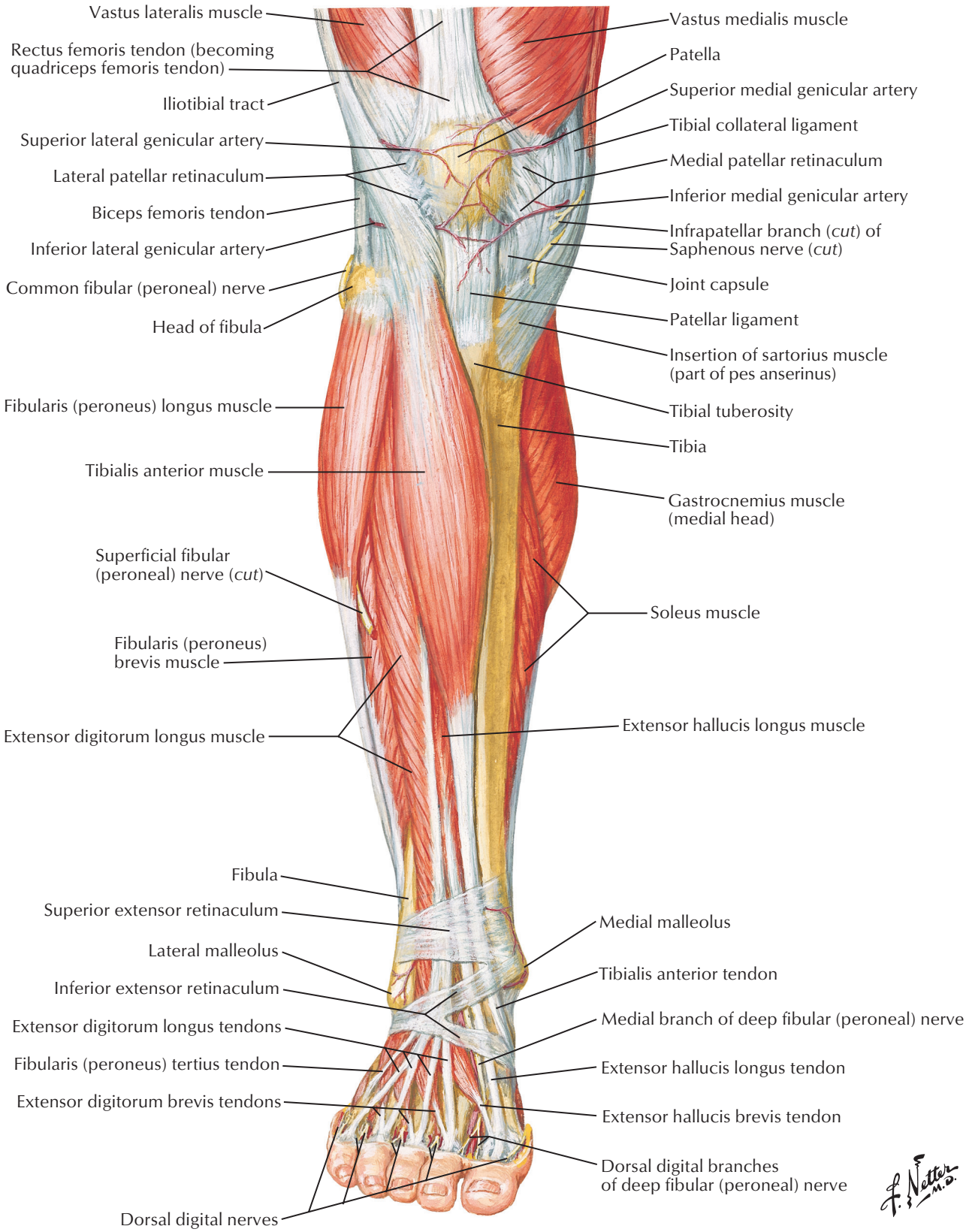
Right leg

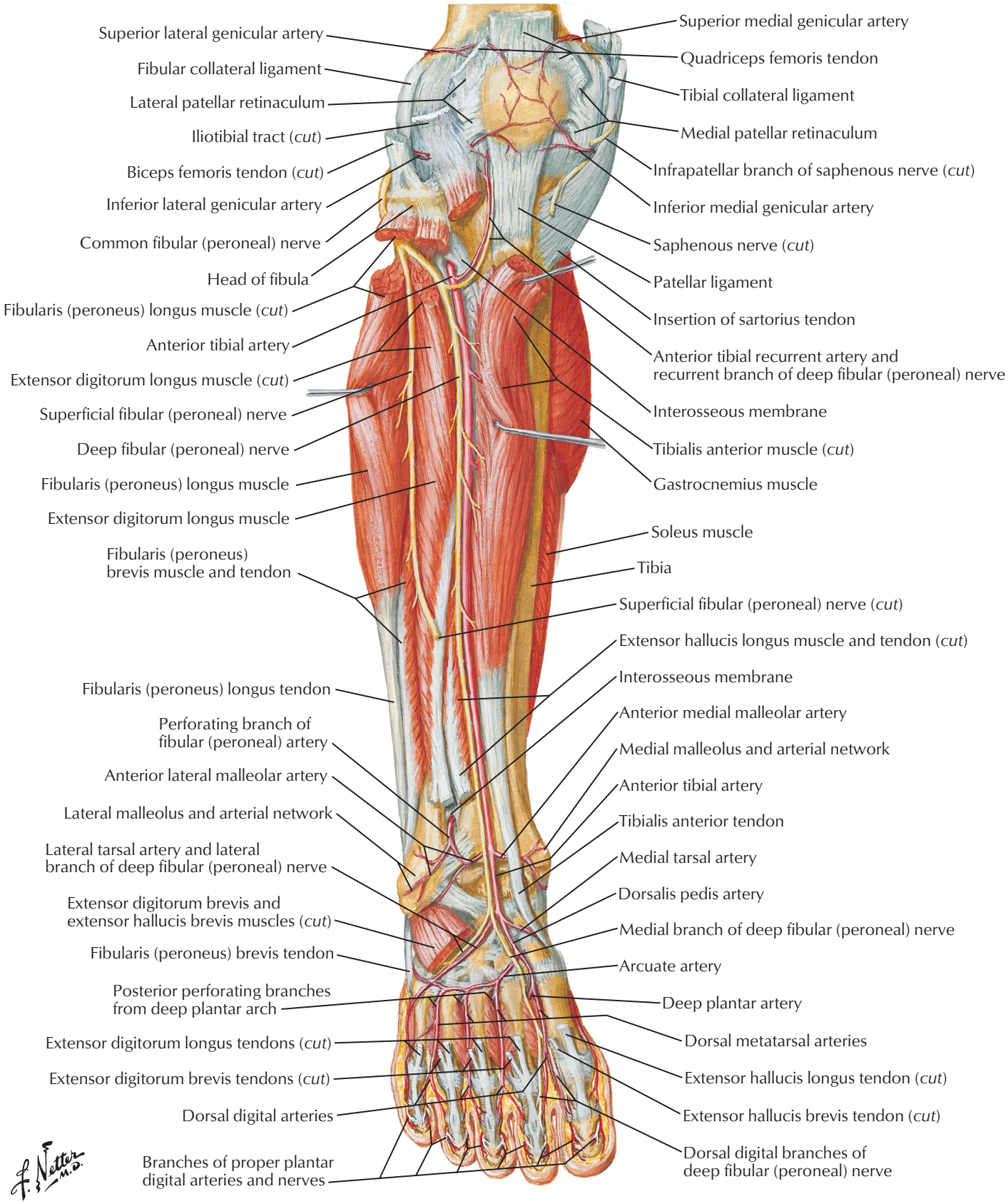



Vastus lateralis muscle
Biceps femoris muscle
Long head
Short head
Tendon
Iliotibial tract
Quadriceps femoris tendon
Superior lateral genicular artery
Patella
Fibular collateral ligament
Lateral patellar retinaculum
Common fibular (peroneal) nerve
Lateral condyle of tibia
Patellar ligament
Inferior lateral genicular artery
Tibial tuberosity
Head of fibula
Tibialis anterior muscle
Gastrocnemius muscle (lateral head)
Extensor digitorum longus muscle
Soleus muscle
Fibularis (peroneus) longus muscle and tendon
Superficial fibular (peroneal) nerve (cut)
Extensor digitorum longus tendon
Extensor hallucis longus muscle and tendon
Fibularis (peroneus) brevis muscle and tendon
Superior extensor retinaculum
Inferior extensor retinaculum
Fibula
Extensor digitorum brevis muscle
Lateral malleolus
Extensor hallucis longus tendon
Calcaneal (Achilles) tendon
Extensor digitorum longus tendons
(Subtendinous) bursa of tendocalcaneus
Fibularis (peroneus) brevis tendon
Superior fibular (peroneal) retinaculum
Fibularis (peroneus) tertius tendon
Inferior fibular (peroneal) retinaculum
5th metatarsal bone
Fibularis (peroneus) longus tendon passing to sole of foot

Muscles of Leg (Superficial Dissection): Anterior View

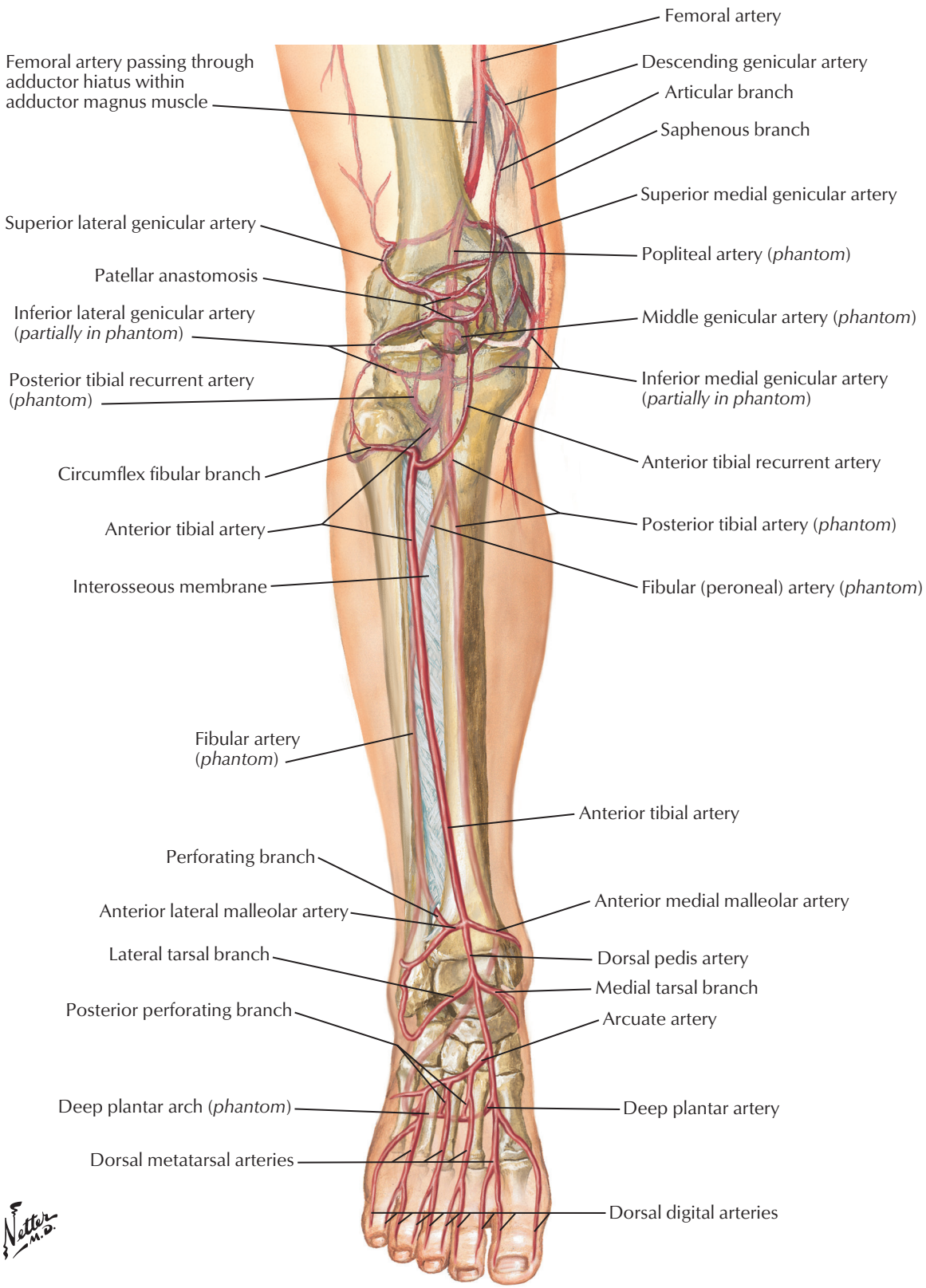
See also Plate 529

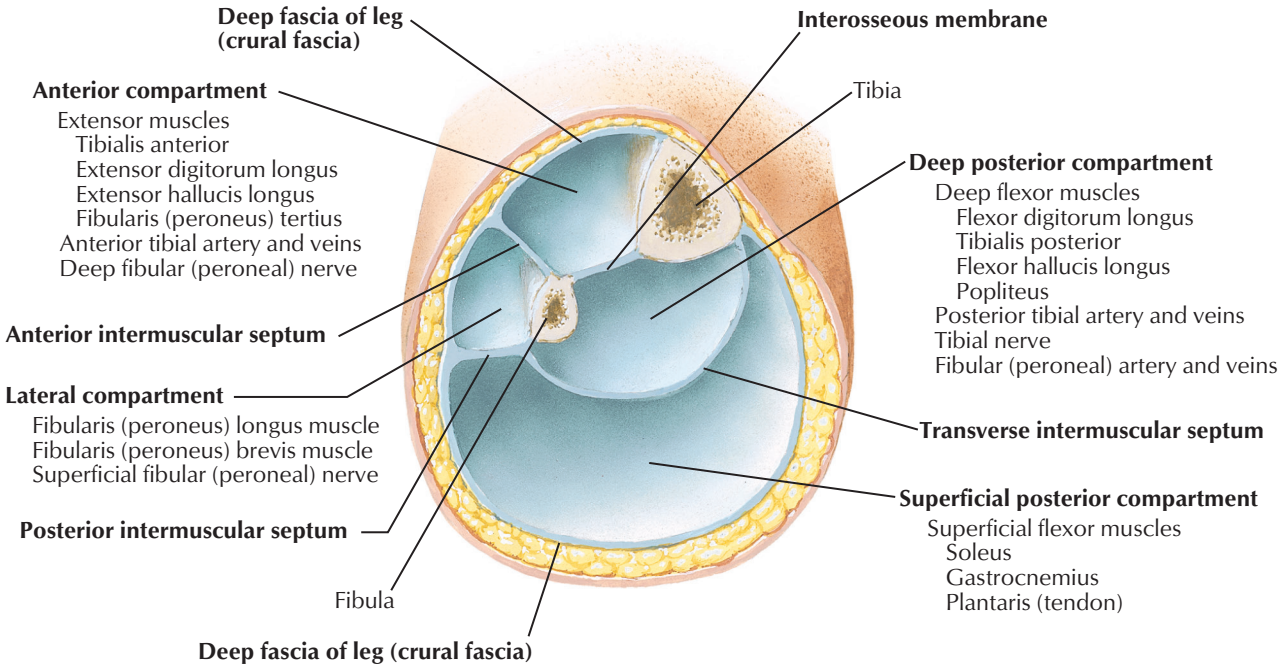



Superior lateral genicular artery
Fibular collateral ligament
Lateral patellar retinaculum
Iliotibial tract (*cut*)
Biceps femoris tendon (*cut*)
Inferior lateral genicular artery
Common fibular (peroneal) nerve
Head of fibula
Fibularis (peroneus) longus muscle (*cut*)
Anterior tibial artery
Extensor digitorum longus muscle (*cut*)
Superficial fibular (peroneal) nerve
Deep fibular (peroneal) nerve
Fibularis (peroneus) longus muscle
Extensor digitorum longus muscle
Fibularis (peroneus) brevis muscle and tendon
Fibularis (peroneus) longus tendon
Perforating branch of fibular (peroneal) artery
Anterior lateral malleolar artery
Lateral malleolus and arterial network
Lateral tarsal artery and lateral branch of deep fibular (peroneal) nerve
Extensor digitorum brevis and extensor hallucis brevis muscles (*cut*)
Fibularis (peroneus) brevis tendon
Posterior perforating branches from deep plantar arch
Extensor digitorum longus tendons (*cut*)
Extensor digitorum brevis tendons (*cut*)
Dorsal digital arteries
Branches of proper plantar digital arteries and nerves
Superior medial genicular artery
Quadriceps femoris tendon
Tibial collateral ligament
Medial patellar retinaculum
Infrapatellar branch of saphenous nerve (*cut*)
Inferior medial genicular artery
Saphenous nerve (*cut*)
Patellar ligament
Insertion of sartorius tendon
Anterior tibial recurrent artery and recurrent branch of deep fibular (peroneal) nerve
Interosseous membrane
Tibialis anterior muscle (*cut*)
Gastrocnemius muscle
Soleus muscle
Tibia
Superficial fibular (peroneal) nerve (*cut*)
Extensor hallucis longus muscle and tendon (*cut*)
Interosseous membrane
Anterior medial malleolar artery
Medial malleolus and arterial network
Anterior tibial artery
Tibialis anterior tendon
Medial tarsal artery
Dorsalis pedis artery
Medial branch of deep fibular (peroneal) nerve
Arcuate artery
Deep plantar artery
Dorsal metatarsal arteries
Extensor hallucis longus tendon (*cut*)
Extensor hallucis brevis tendon (*cut*)
Dorsal digital branches of deep fibular (peroneal) nerve

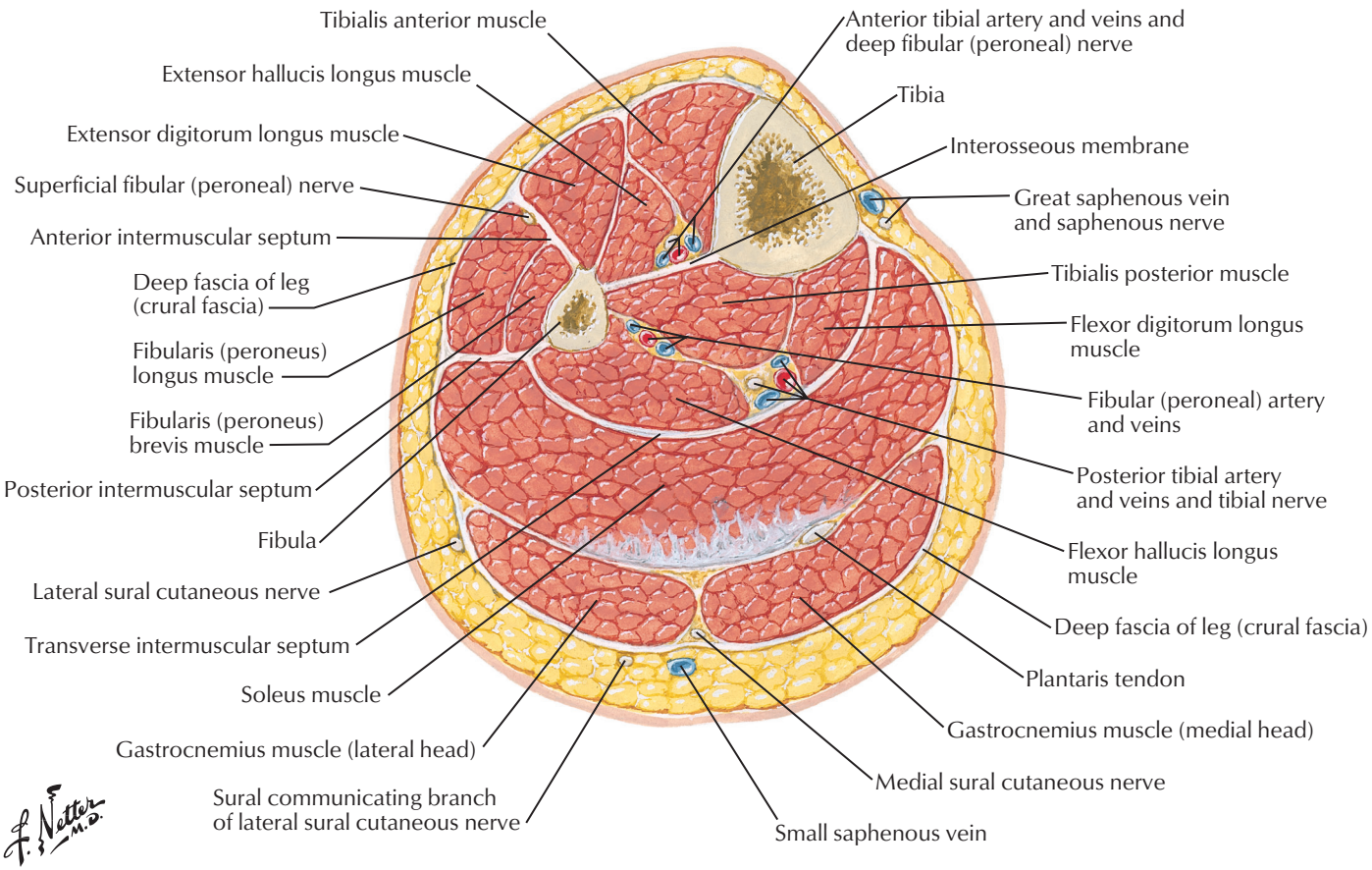
Arteries of Knee, Leg, and Foot

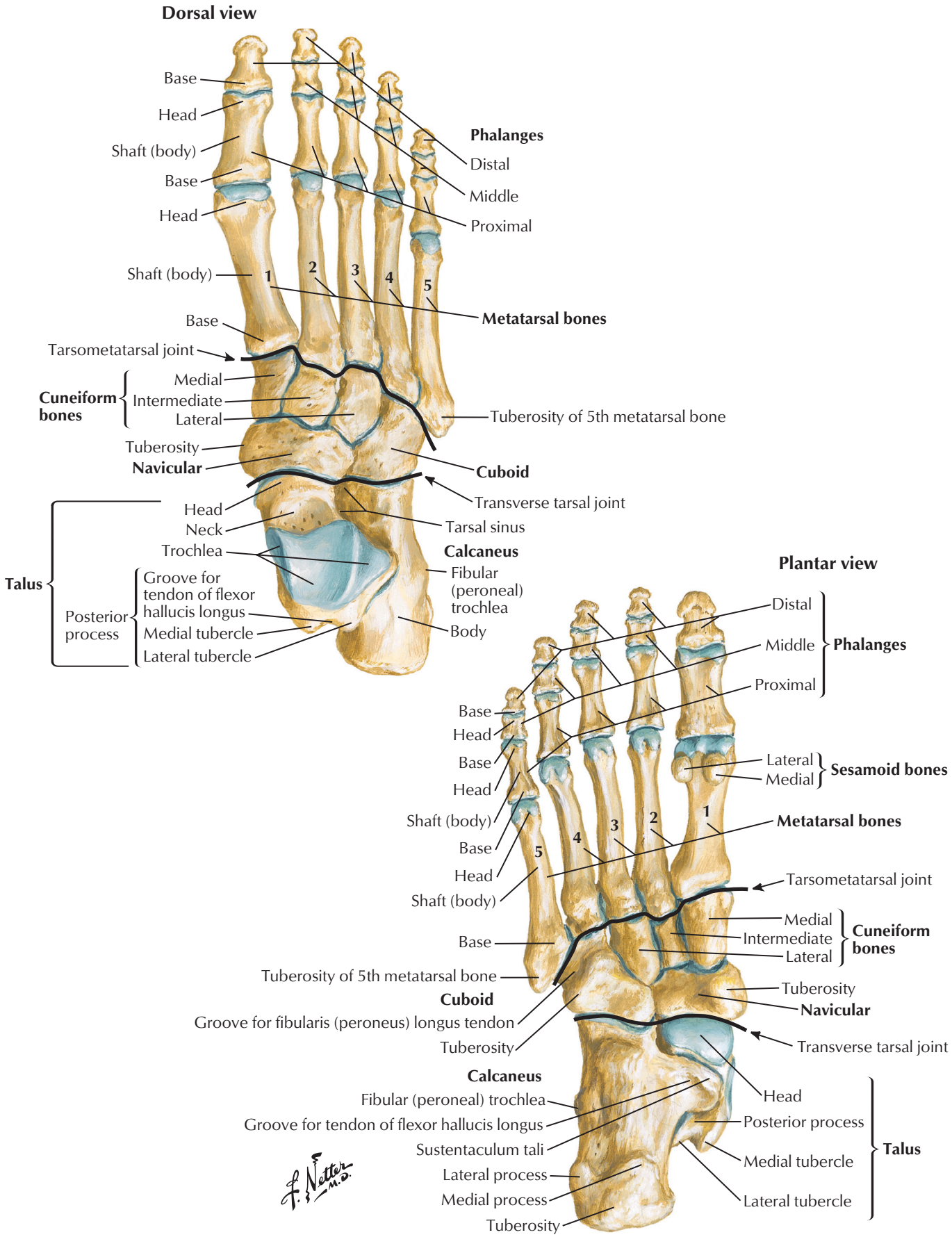
See also Plate 531



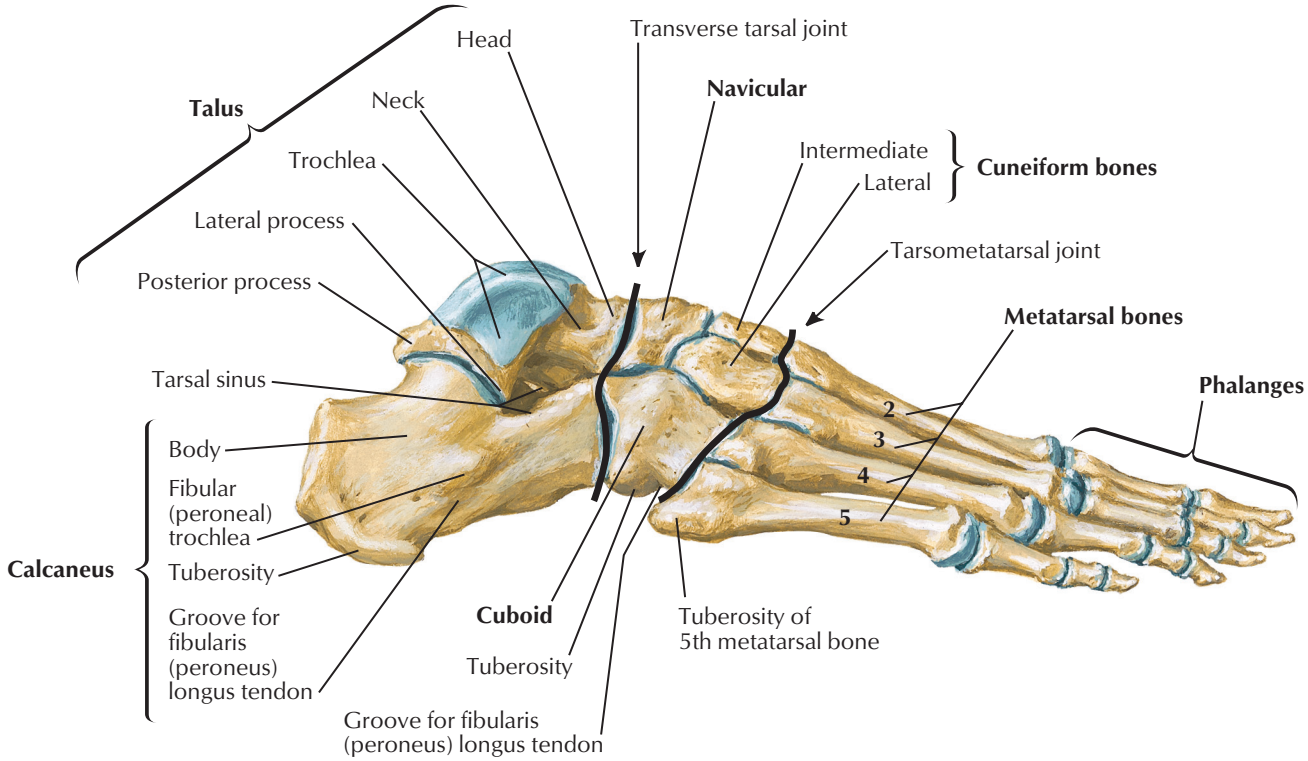


Cross section just above middle of leg

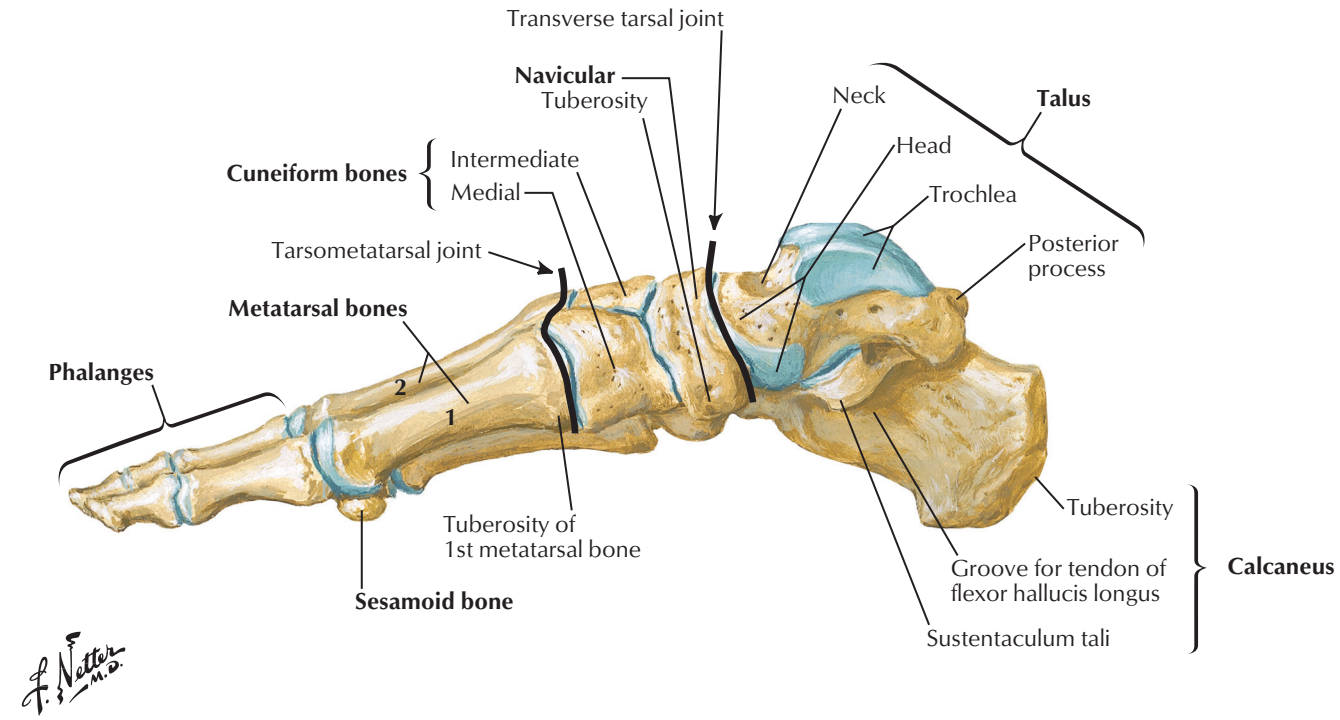



Dorsal view
Base
Head
Shaft (body)
Base
Head
Phalanges
Distal
Middle
Proximal
Shaft (body)
1
2
3
4
5
Metatarsal bones
Base
Tarsometatarsal joint
Cuneiform bones
Medial
Intermediate
Lateral
Tuberosity of 5th metatarsal bone
Tuberosity
Navicular
Cuboid
Transverse tarsal joint
Talus
Head
Neck
Trochlea
Tarsal sinus
Calcaneus
Fibular (peroneal) trochlea
Posterior process
Groove for tendon of flexor hallucis longus
Medial tubercle
Lateral tubercle
Body
Plantar view
Distal
Middle
Proximal
Phalanges
Base
Head
Base
Head
Lateral
Medial
Sesamoid bones
Shaft (body)
Base
Head
Shaft (body)
1
2
3
4
5
Metatarsal bones
Tarsometatarsal joint
Medial
Intermediate
Lateral
Cuneiform bones
Base
Tuberosity of 5th metatarsal bone
Cuboid
Groove for fibularis (peroneus) longus tendon
Tuberosity
Tuberosity
Navicular
Transverse tarsal joint
Calcaneus
Fibular (peroneal) trochlea
Groove for tendon of flexor hallucis longus
Sustentaculum tali
Lateral process
Medial process
Tuberosity
Head
Posterior process
Medial tubercle
Lateral tubercle
Talus

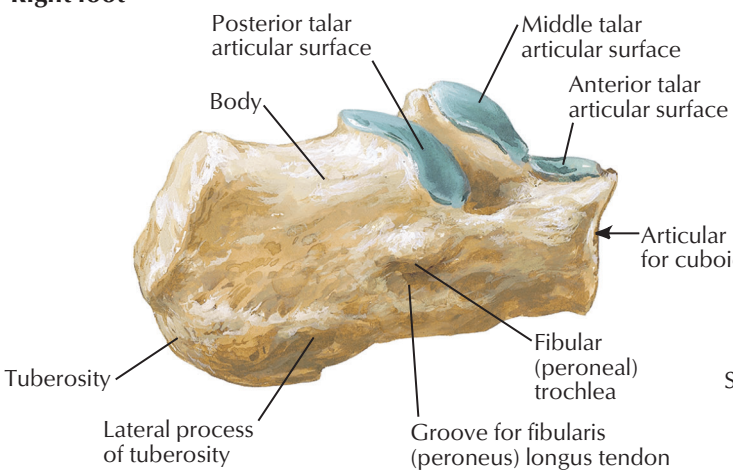
Lateral view



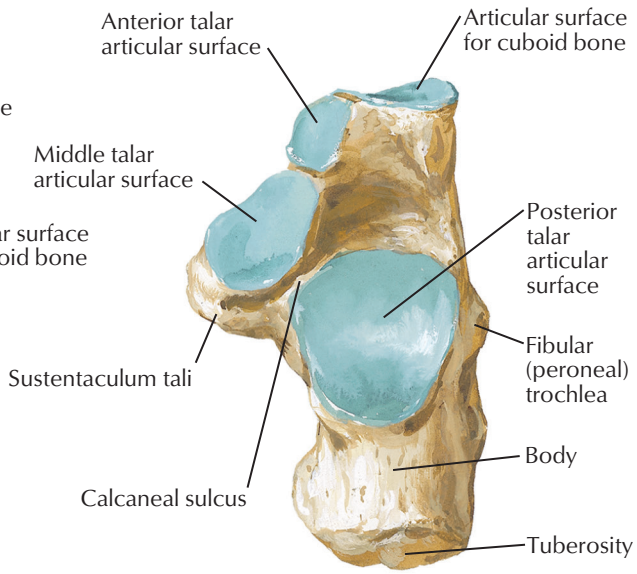
Medial view



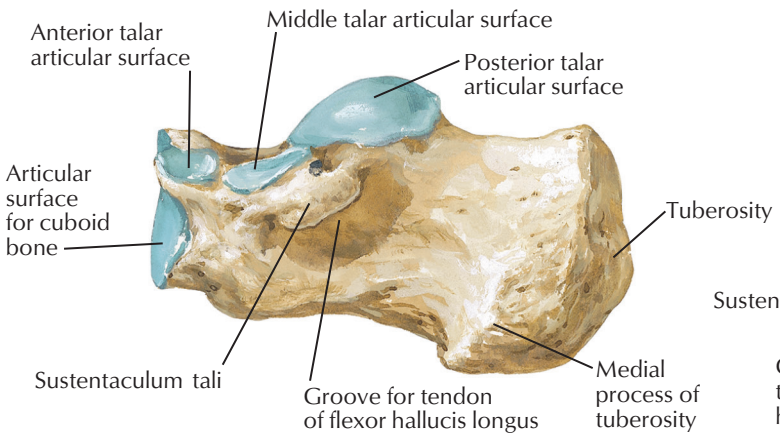
Right foot



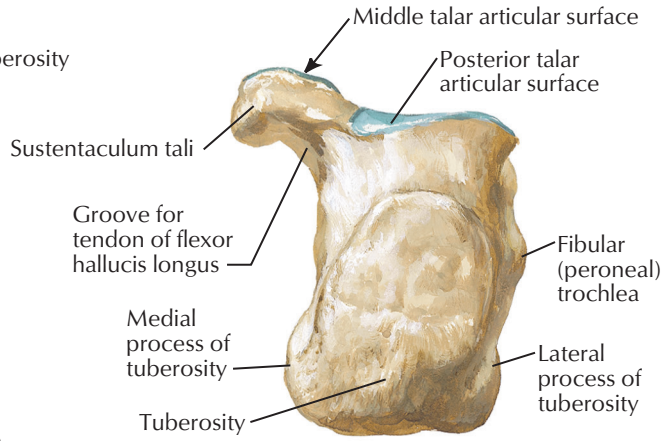
Lateral view



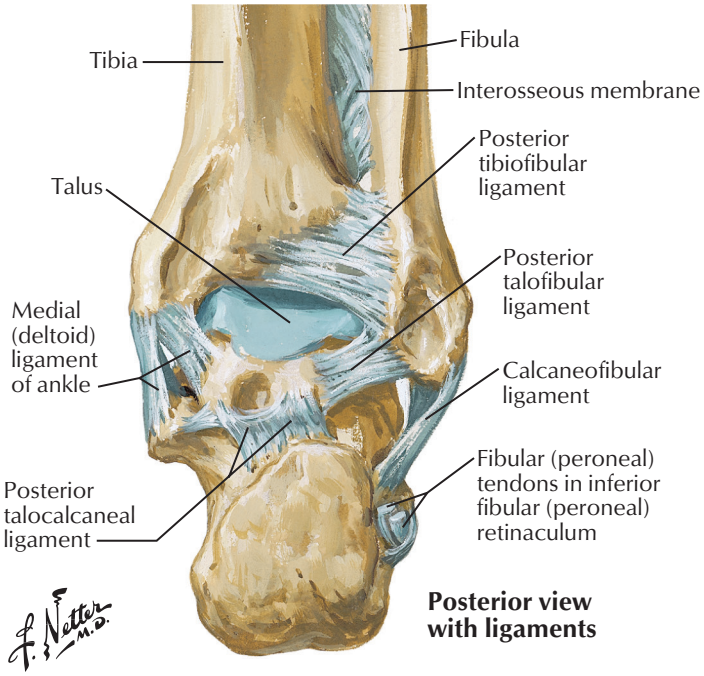
Superior view



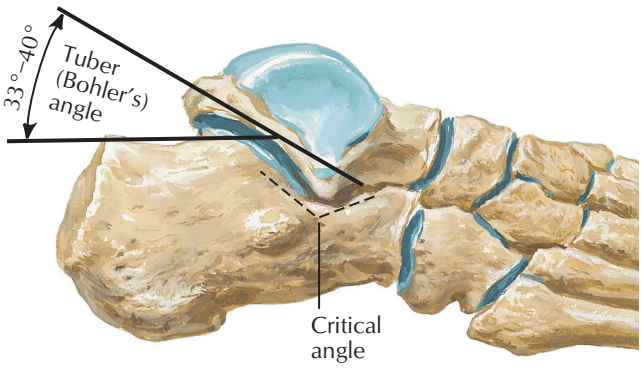
Medial view



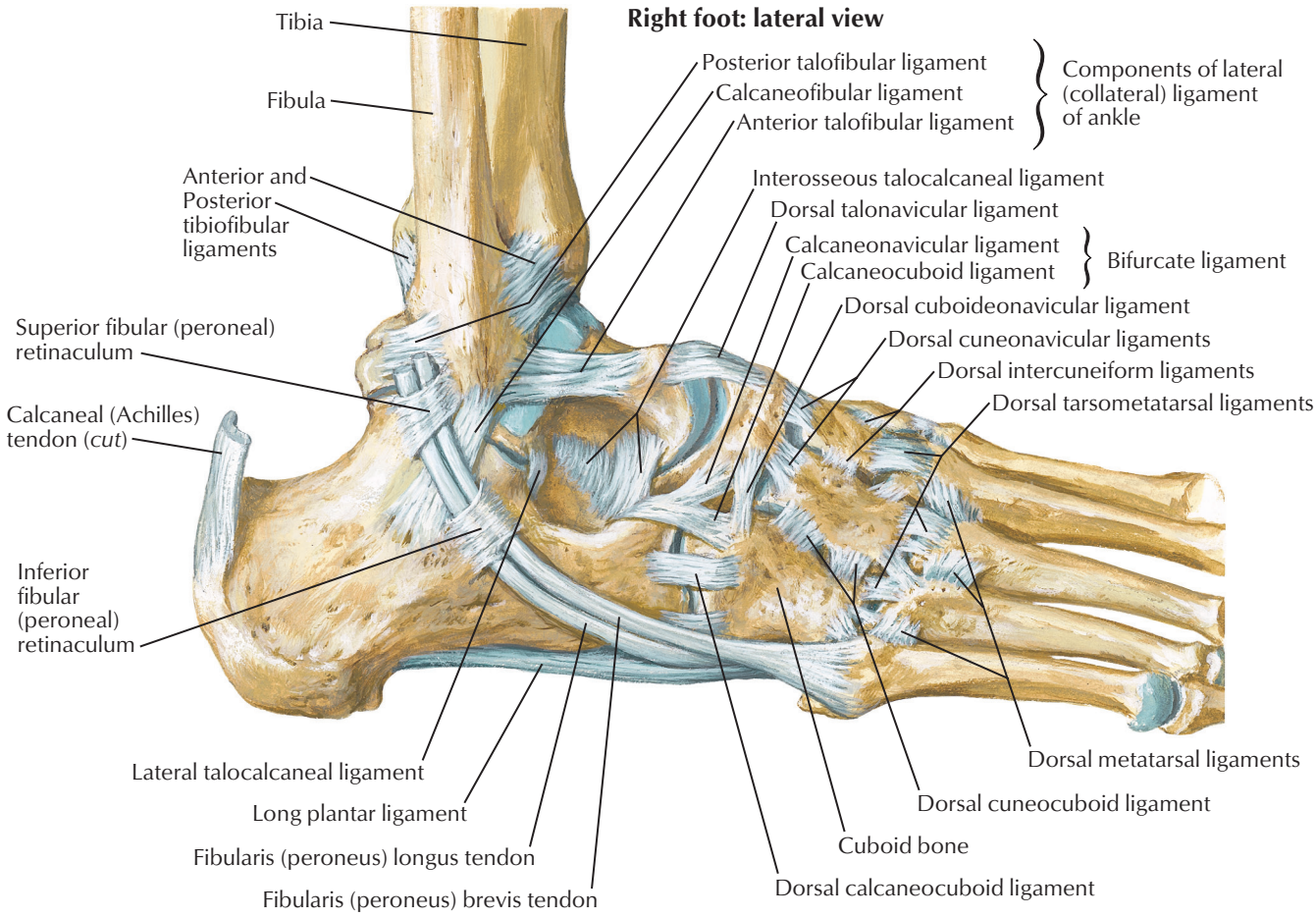
Posterior view

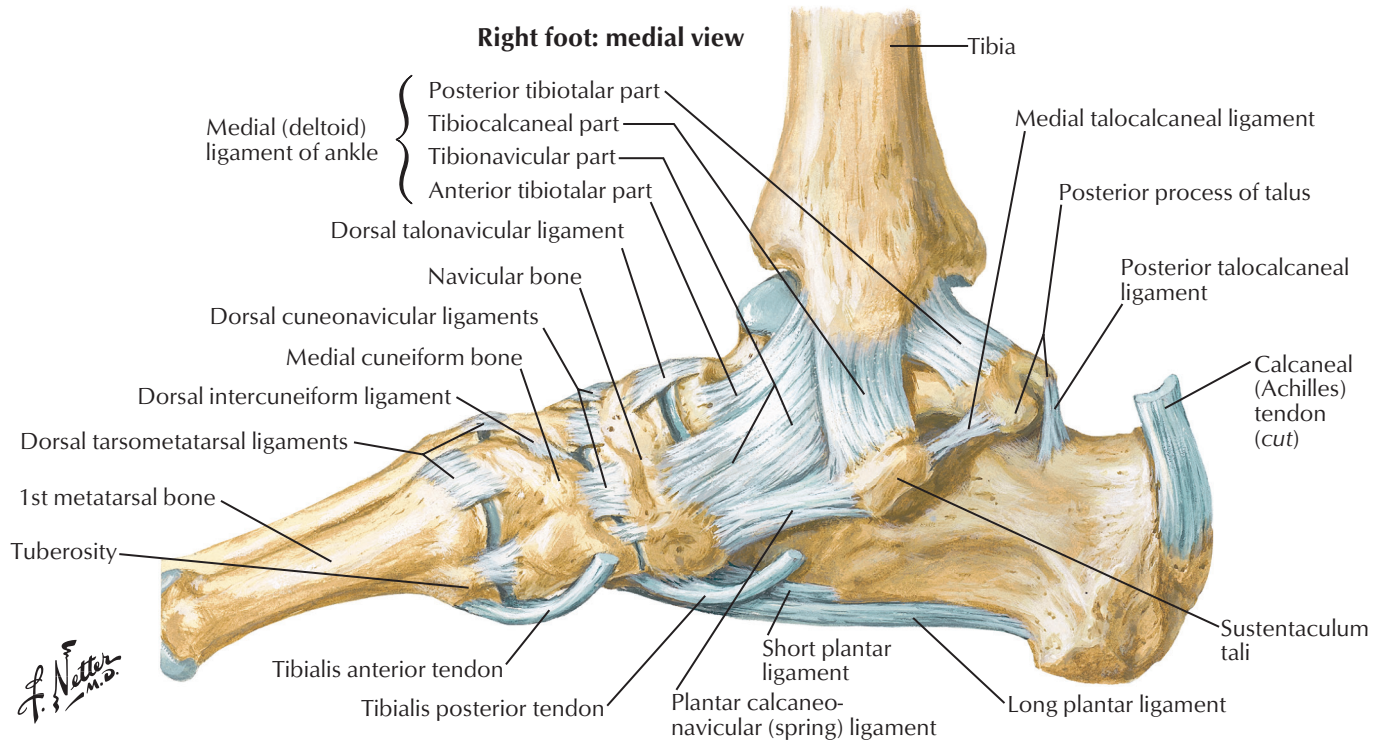


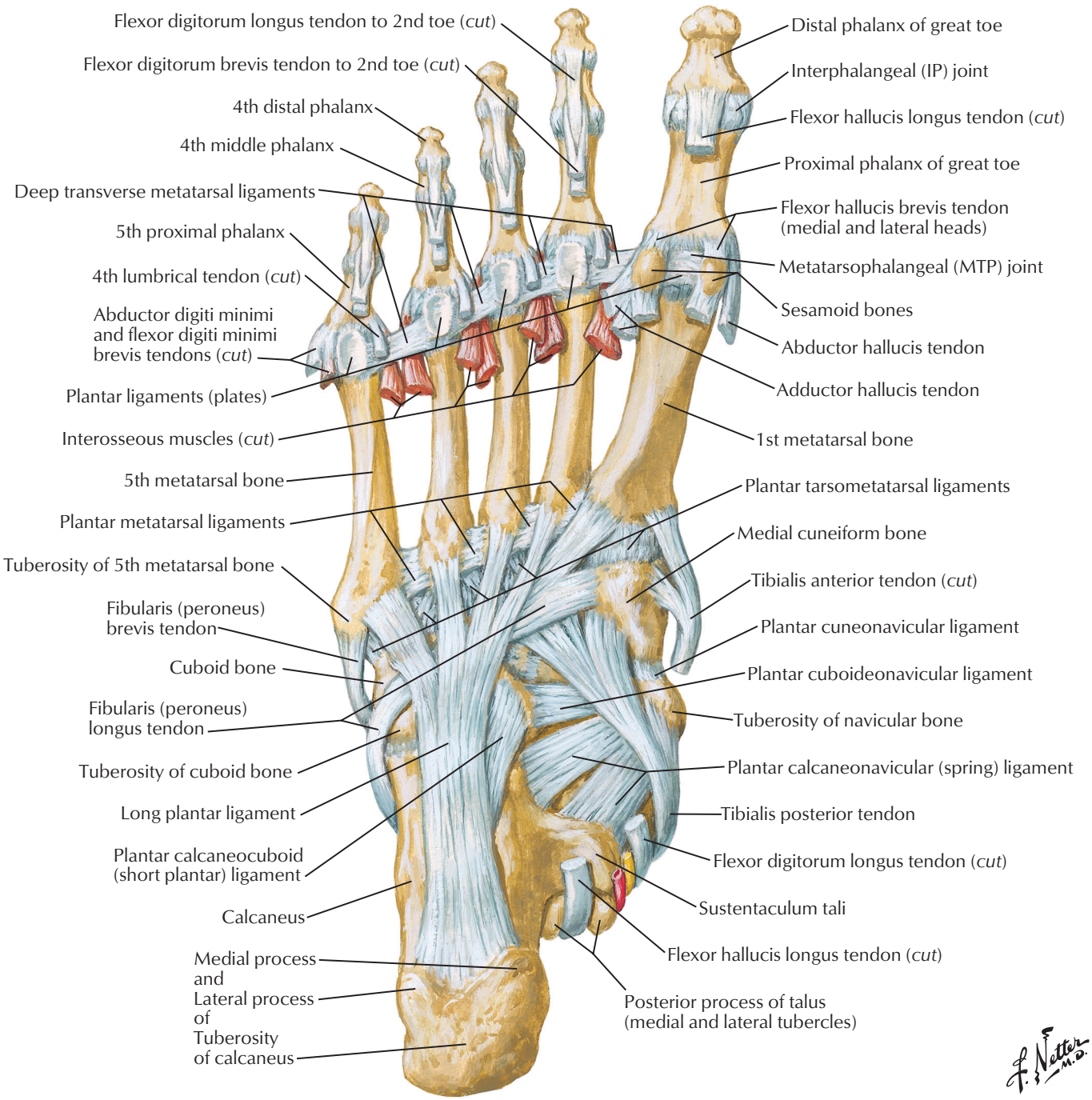
Posterior view with ligaments

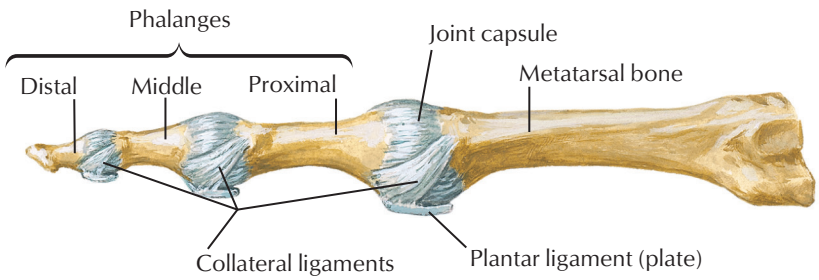


Functional relations of calcaneus

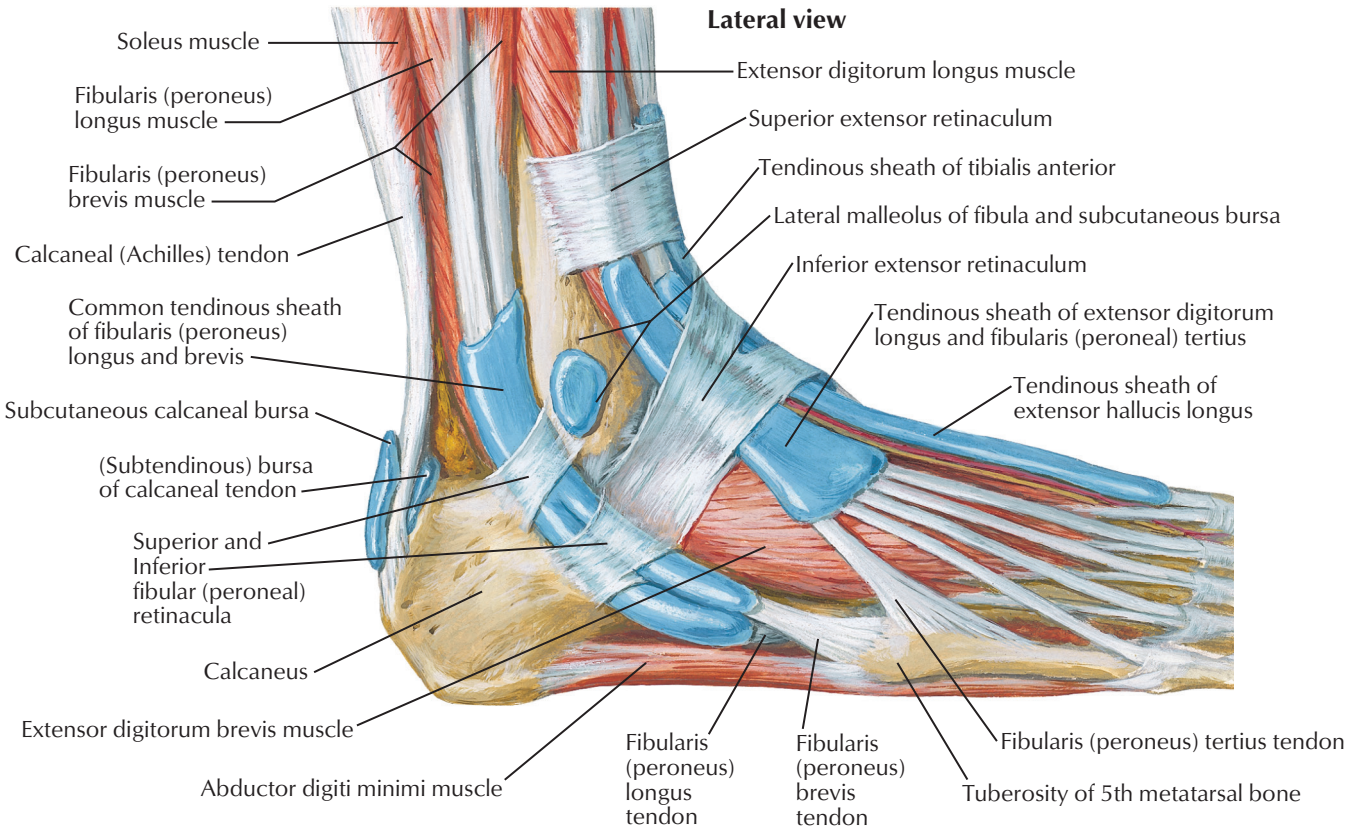

Right foot: lateral view
Tibia
Fibula
Anterior and Posterior tibiofibular ligaments
Superior fibular (peroneal) retinaculum
Calcaneal (Achilles) tendon (cut)
Inferior fibular (peroneal) retinaculum
Lateral talocalcaneal ligament
Long plantar ligament
Fibularis (peroneus) longus tendon
Fibularis (peroneus) brevis tendon
Posterior talofibular ligament
Calcaneofibular ligament
Anterior talofibular ligament
Components of lateral (collateral) ligament of ankle
Interosseous talocalcaneal ligament
Dorsal talonavicular ligament
Calcaneonavicular ligament
Calcaneocuboid ligament
Bifurcate ligament
Dorsal cuboideonavicular ligament
Dorsal cuneonavicular ligaments
Dorsal intercuneiform ligaments
Dorsal tarsometatarsal ligaments
Dorsal metatarsal ligaments
Dorsal cuneocuboid ligament
Cuboid bone
Dorsal calcaneocuboid ligament

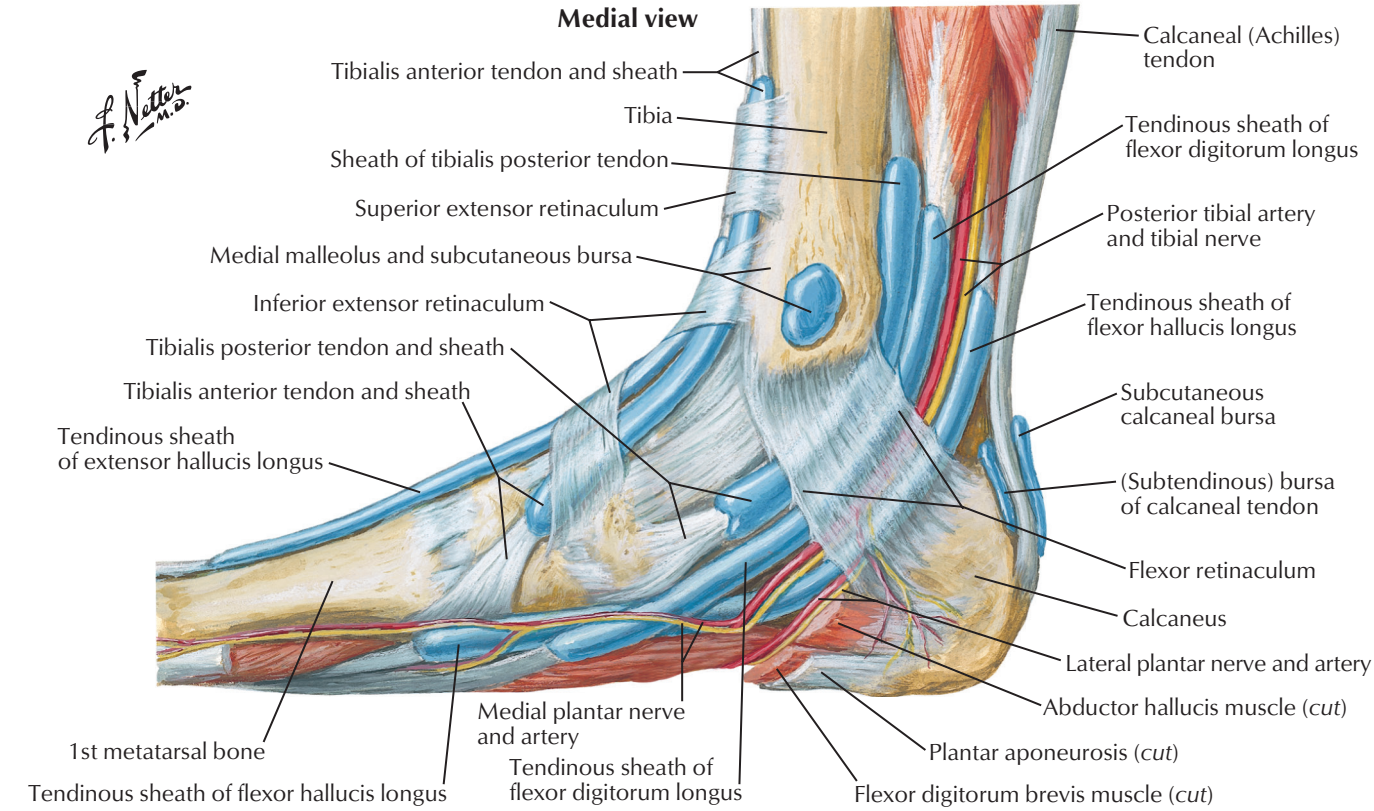

Right foot: medial view
Tibia
Medial (deltoid) ligament of ankle
Posterior tibiotalar part
Tibiocalcaneal part
Tibionavicular part
Anterior tibiotalar part
Medial talocalcaneal ligament
Posterior process of talus
Dorsal talonavicular ligament
Navicular bone
Posterior talocalcaneal ligament
Dorsal cuneonavicular ligaments
Medial cuneiform bone
Dorsal intercuneiform ligament
Calcaneal (Achilles) tendon (cut)
Dorsal tarsometatarsal ligaments
1st metatarsal bone
Tuberosity
Sustentaculum tali
Short plantar ligament
Tibialis anterior tendon
Tibialis posterior tendon
Plantar calcaneo-navicular (spring) ligament
Long plantar ligament





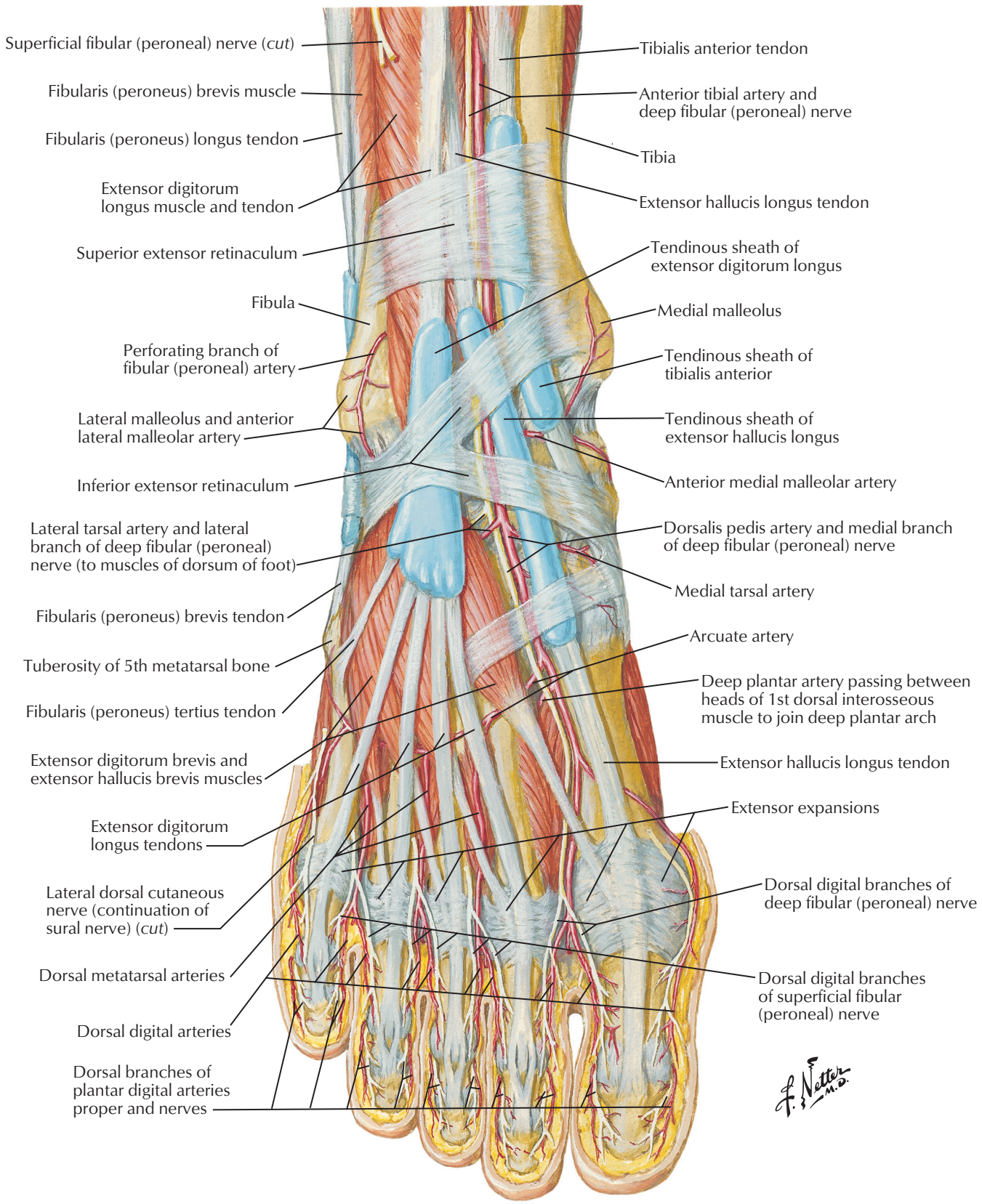
Capsules and ligaments of metatarsophalangeal and interphalangeal joints: lateral view

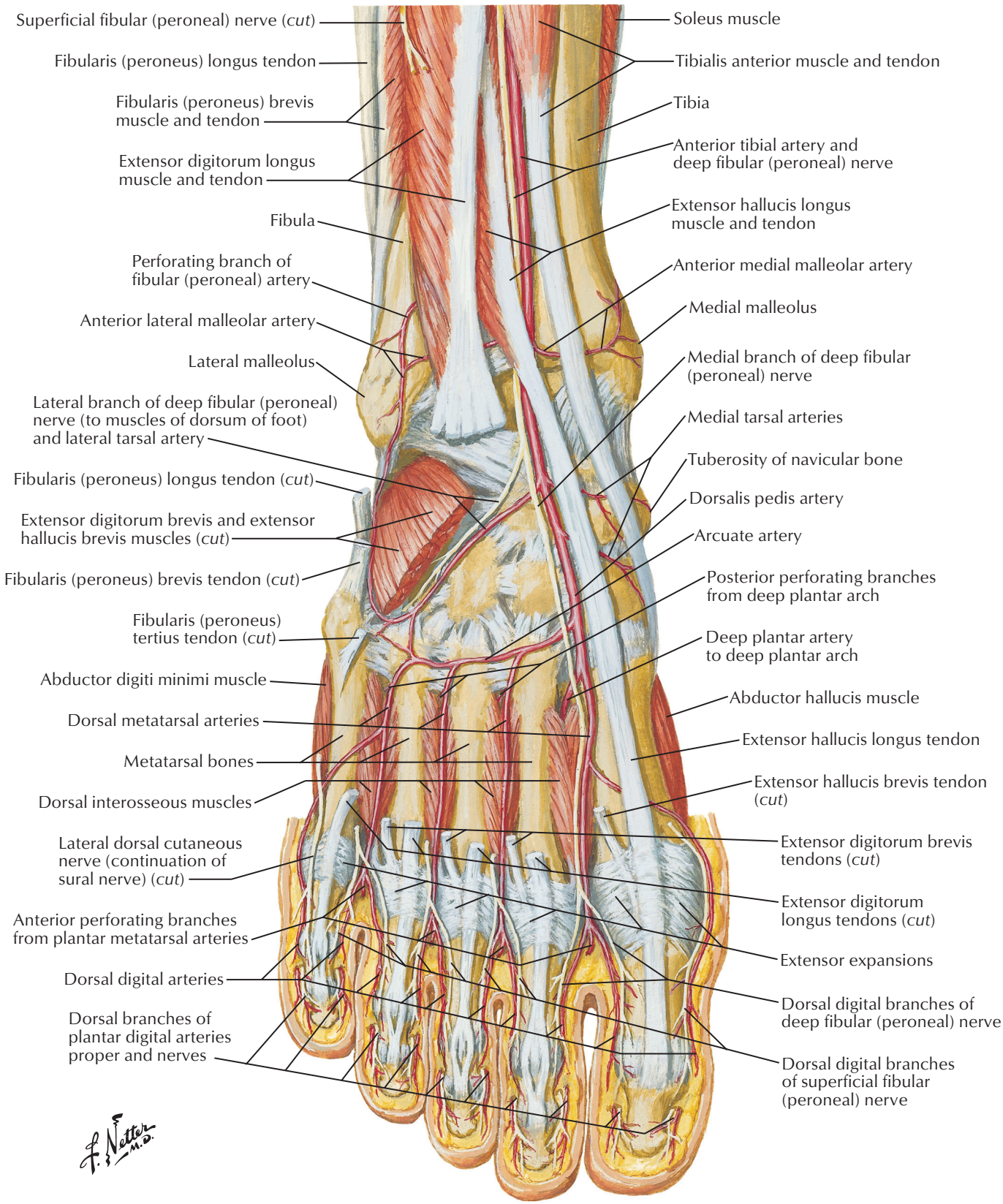

Lateral view
Soleus muscle
Fibularis (peroneus) longus muscle
Fibularis (peroneus) brevis muscle
Calcaneal (Achilles) tendon
Common tendinous sheath of fibularis (peroneus) longus and brevis
Subcutaneous calcaneal bursa
(Subtendinous) bursa of calcaneal tendon
Superior and Inferior fibular (peroneal) retinacula
Calcaneus
Extensor digitorum brevis muscle
Abductor digiti minimi muscle
Extensor digitorum longus muscle
Superior extensor retinaculum
Tendinous sheath of tibialis anterior
Lateral malleolus of fibula and subcutaneous bursa
Inferior extensor retinaculum
Tendinous sheath of extensor digitorum longus and fibularis (peroneal) tertius
Tendinous sheath of extensor hallucis longus
Fibularis (peroneus) longus tendon
Fibularis (peroneus) brevis tendon
Fibularis (peroneus) tertius tendon
Tuberosity of 5th metatarsal bone

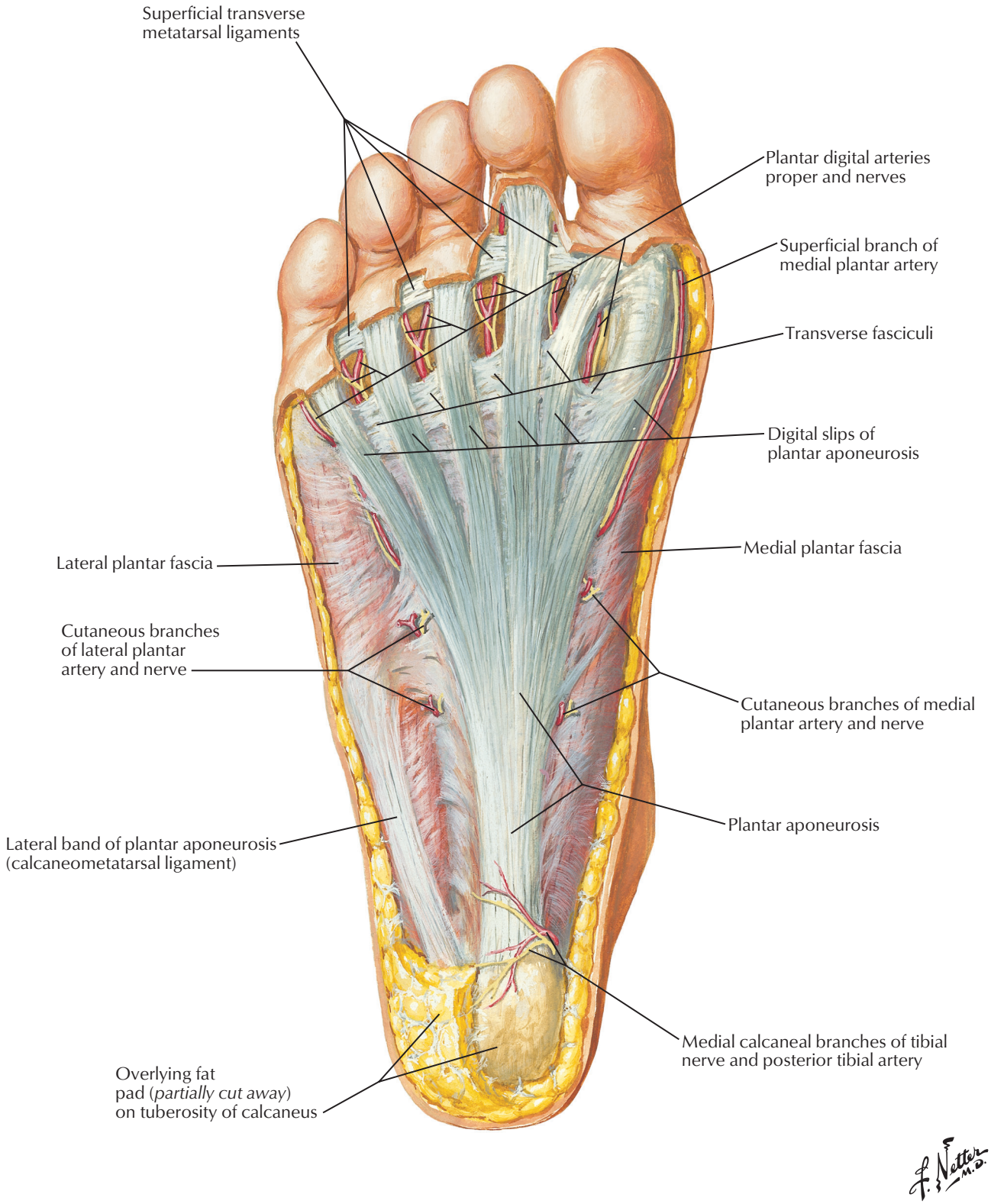

Medial view
Tibialis anterior tendon and sheath
Tibia
Sheath of tibialis posterior tendon
Superior extensor retinaculum
Medial malleolus and subcutaneous bursa
Inferior extensor retinaculum
Tibialis posterior tendon and sheath
Tibialis anterior tendon and sheath
Tendinous sheath of extensor hallucis longus
1st metatarsal bone
Tendinous sheath of flexor hallucis longus
Medial plantar nerve and artery
Tendinous sheath of flexor digitorum longus
Calcaneal (Achilles) tendon
Tendinous sheath of flexor digitorum longus
Posterior tibial artery and tibial nerve
Tendinous sheath of flexor hallucis longus
Subcutaneous calcaneal bursa
(Subtendinous) bursa of calcaneal tendon
Flexor retinaculum
Calcaneus
Lateral plantar nerve and artery
Abductor hallucis muscle (cut)
Plantar aponeurosis (cut)
Flexor digitorum brevis muscle (cut)

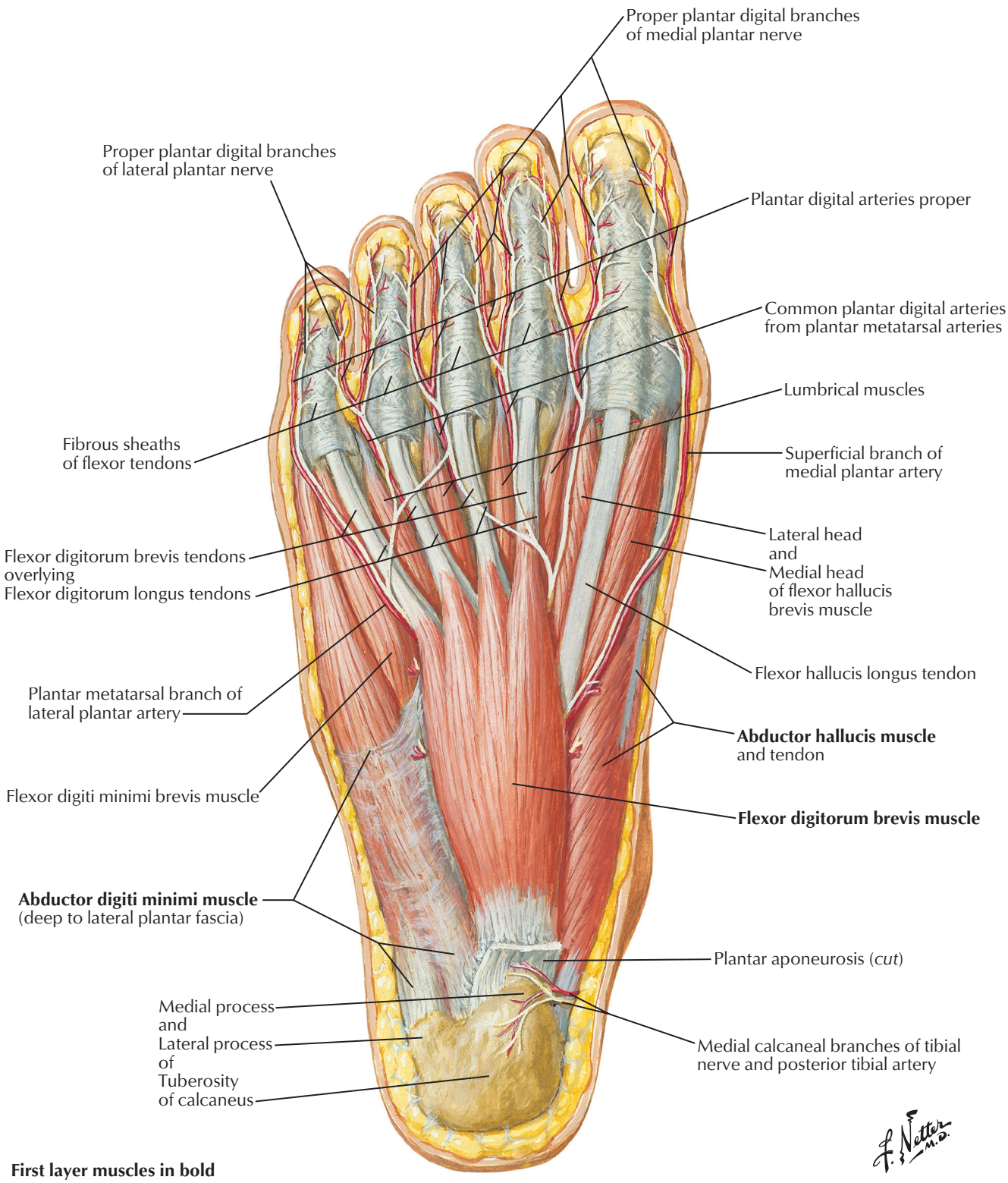
Muscles of Dorsum of Foot: Superficial Dissection

See also Plate 529




Superficial fibular (peroneal) nerve (*cut*)
Fibularis (peroneus) longus tendon
Fibularis (peroneus) brevis muscle and tendon
Extensor digitorum longus muscle and tendon
Fibula
Perforating branch of fibular (peroneal) artery
Anterior lateral malleolar artery
Lateral malleolus
Lateral branch of deep fibular (peroneal) nerve (to muscles of dorsum of foot) and lateral tarsal artery
Fibularis (peroneus) longus tendon (*cut*)
Extensor digitorum brevis and extensor hallucis brevis muscles (*cut*)
Fibularis (peroneus) brevis tendon (*cut*)
Fibularis (peroneus) tertius tendon (*cut*)
Abductor digiti minimi muscle
Dorsal metatarsal arteries
Metatarsal bones
Dorsal interosseous muscles
Lateral dorsal cutaneous nerve (continuation of sural nerve) (*cut*)
Anterior perforating branches from plantar metatarsal arteries
Dorsal digital arteries
Dorsal branches of plantar digital arteries proper and nerves
Soleus muscle
Tibialis anterior muscle and tendon
Tibia
Anterior tibial artery and deep fibular (peroneal) nerve
Extensor hallucis longus muscle and tendon
Anterior medial malleolar artery
Medial malleolus
Medial branch of deep fibular (peroneal) nerve
Medial tarsal arteries
Tuberosity of navicular bone
Dorsalis pedis artery
Arcuate artery
Posterior perforating branches from deep plantar arch
Deep plantar artery to deep plantar arch
Abductor hallucis muscle
Extensor hallucis longus tendon
Extensor hallucis brevis tendon (*cut*)
Extensor digitorum brevis tendons (*cut*)
Extensor digitorum longus tendons (*cut*)
Extensor expansions
Dorsal digital branches of deep fibular (peroneal) nerve
Dorsal digital branches of superficial fibular (peroneal) nerve

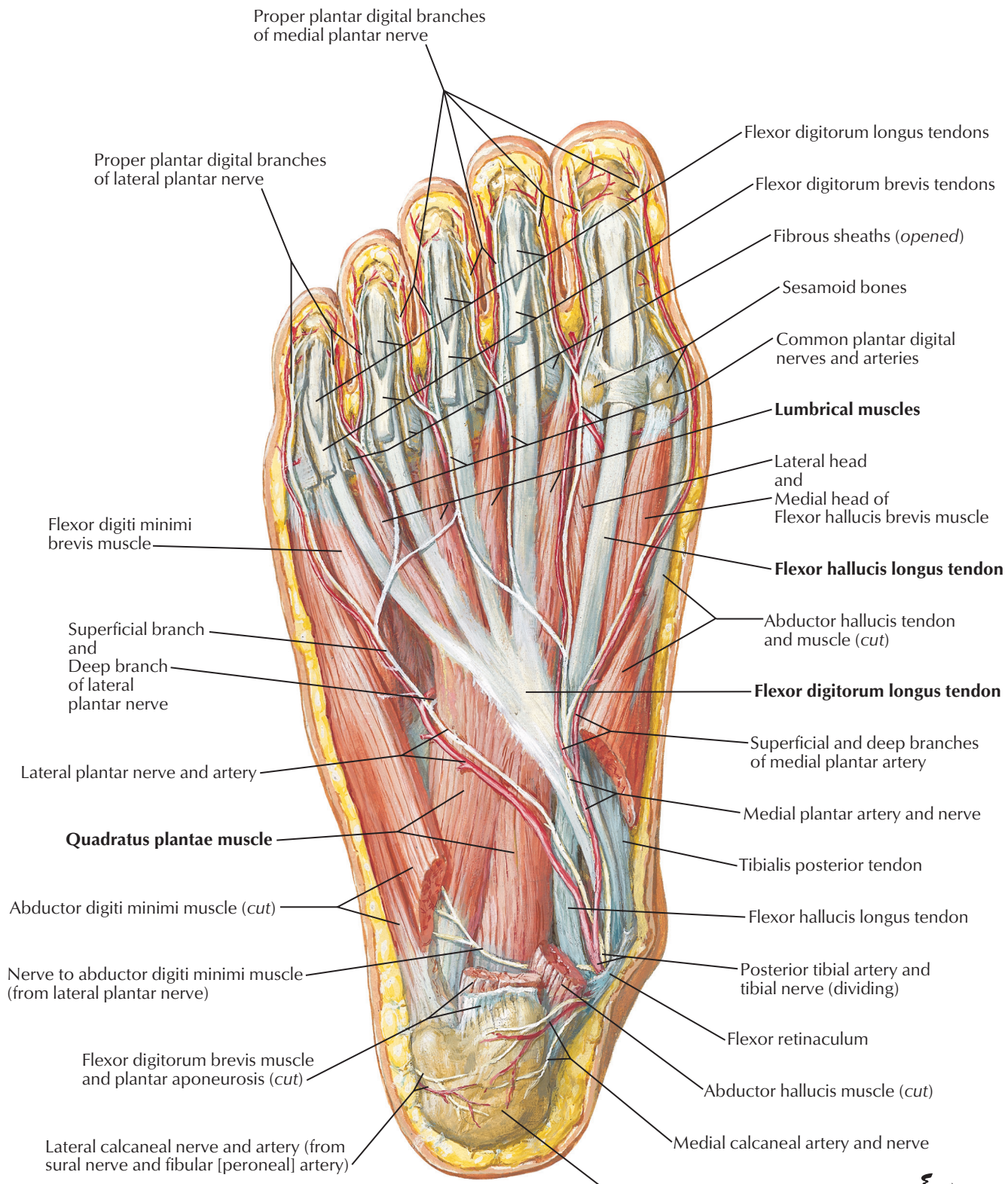

Superficial transverse metatarsal ligaments
Plantar digital arteries proper and nerves
Superficial branch of medial plantar artery
Transverse fasciculi
Digital slips of plantar aponeurosis
Lateral plantar fascia
Medial plantar fascia
Cutaneous branches of lateral plantar artery and nerve
Cutaneous branches of medial plantar artery and nerve
Plantar aponeurosis
Lateral band of plantar aponeurosis (calcaneometatarsal ligament)
Medial calcaneal branches of tibial nerve and posterior tibial artery
Overlying fat pad (*partially cut away*) on tuberosity of calcaneus



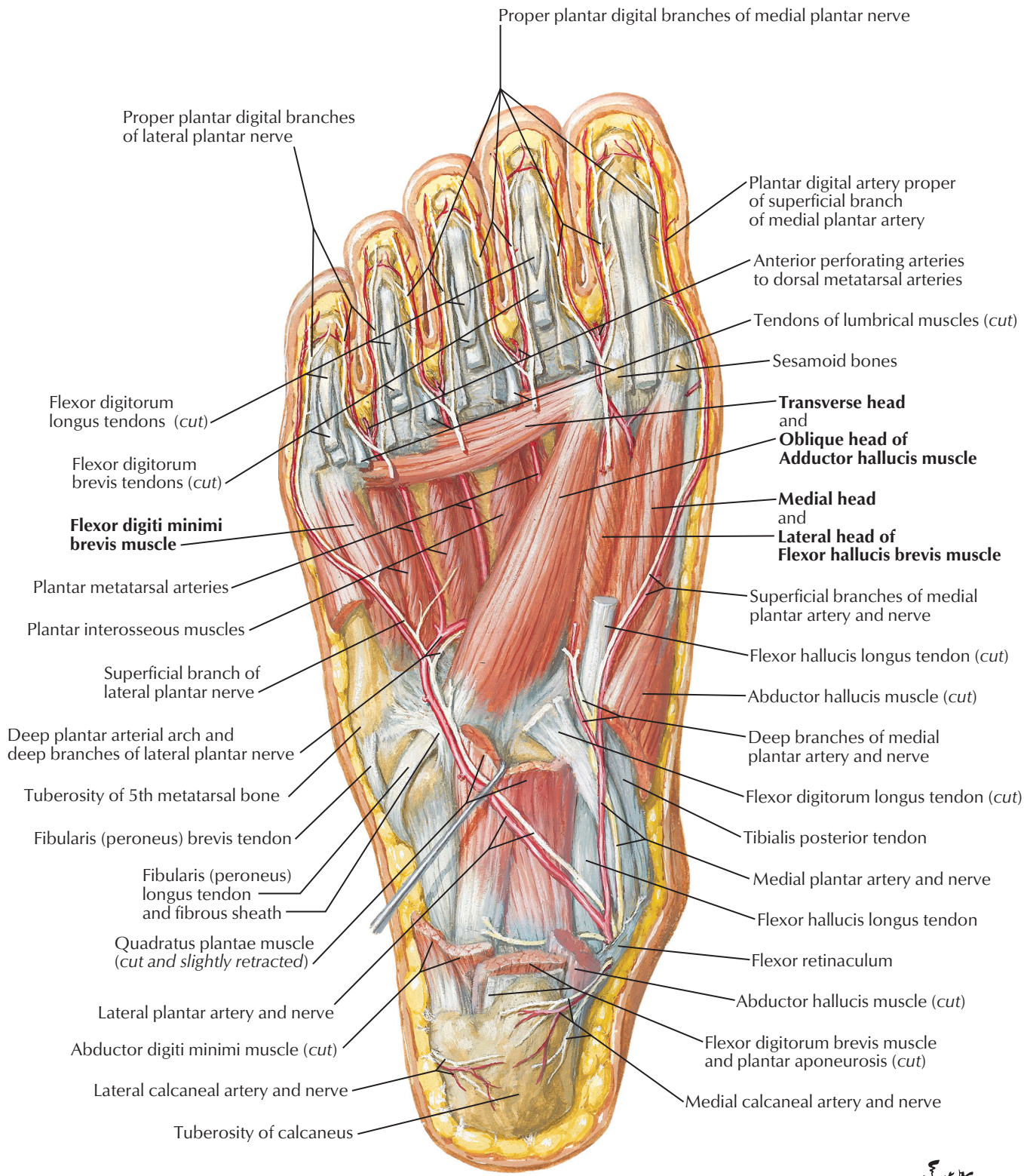
First layer muscles in bold

Muscles of Sole of Foot: Second Layer

See also Plate 528



Second layer tendons and muscles in bold

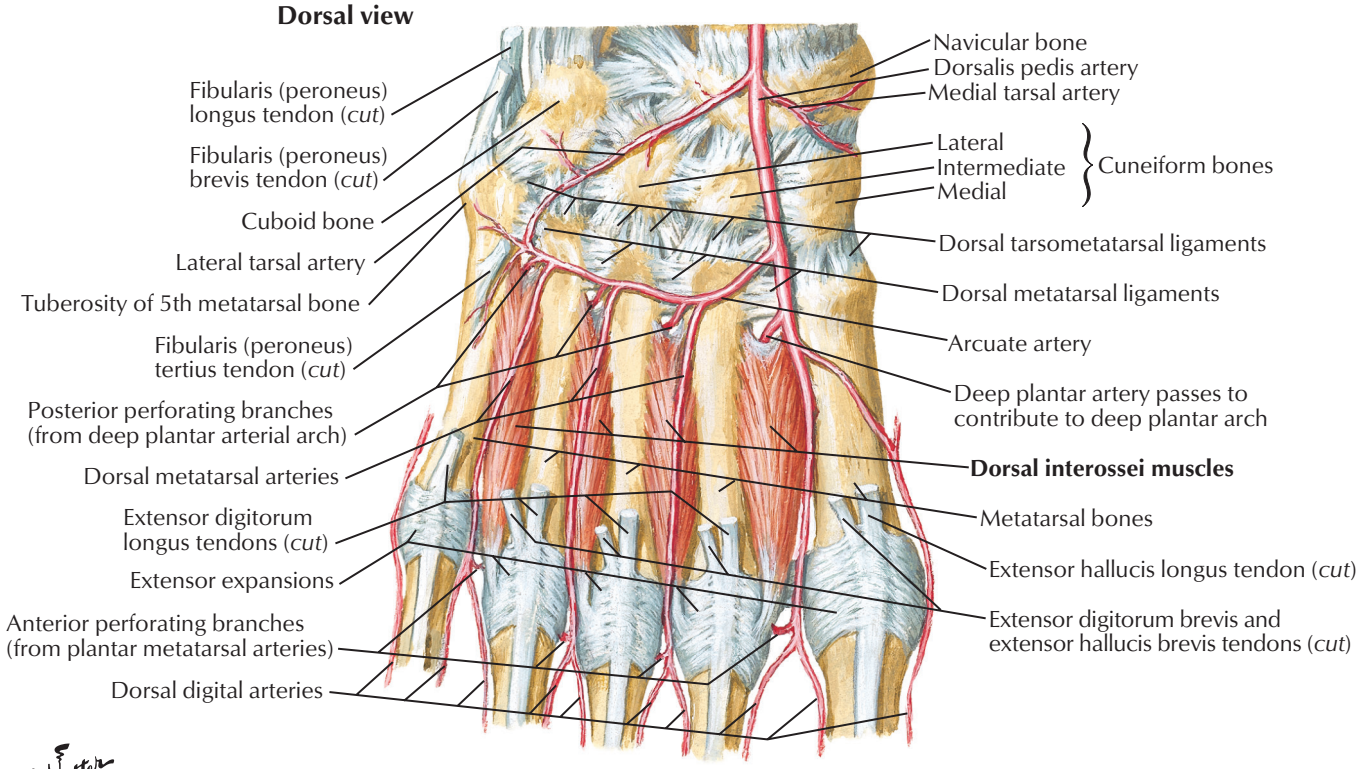


Third layer muscles in bold

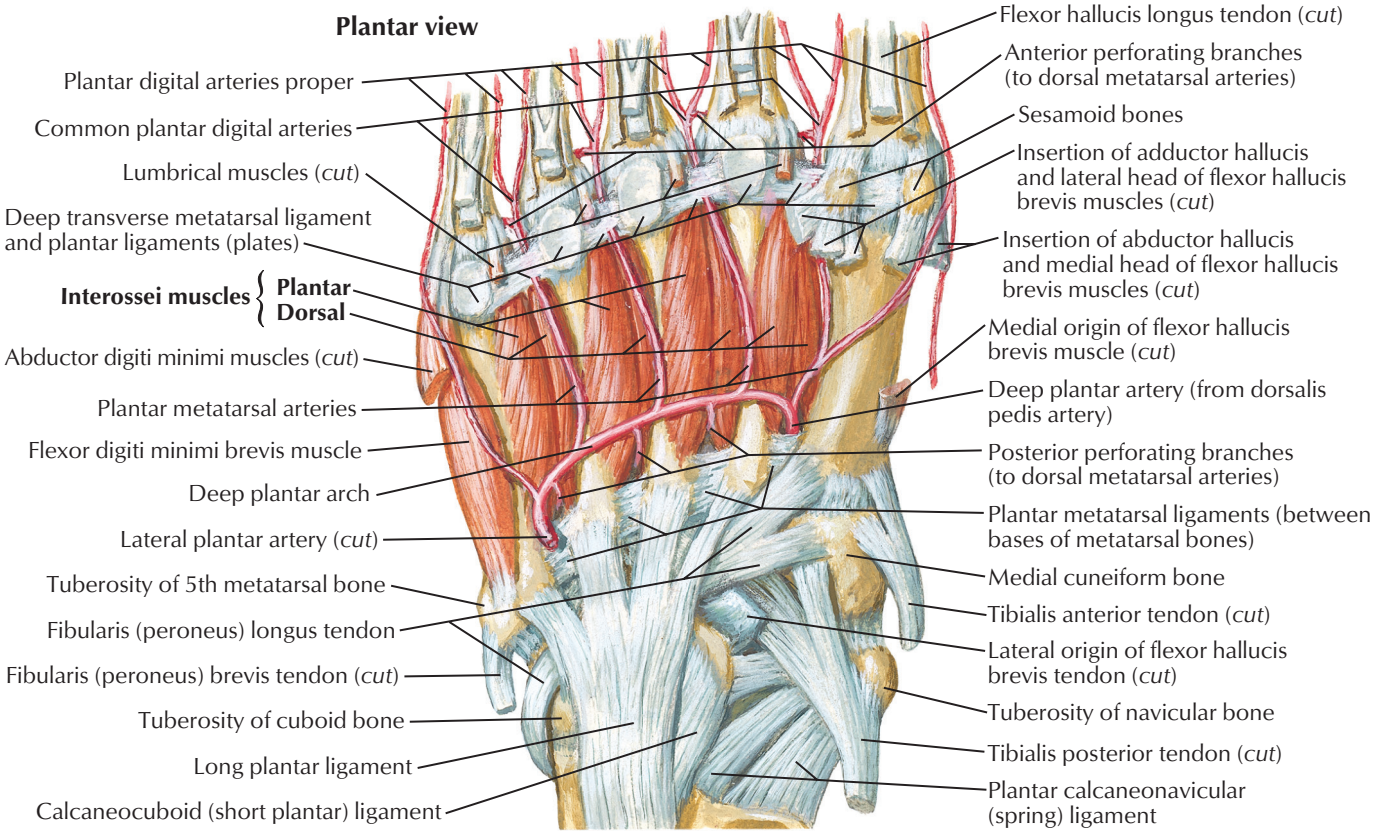
Interosseous Muscles and Deep Arteries of Foot

See also Plates 508, 518

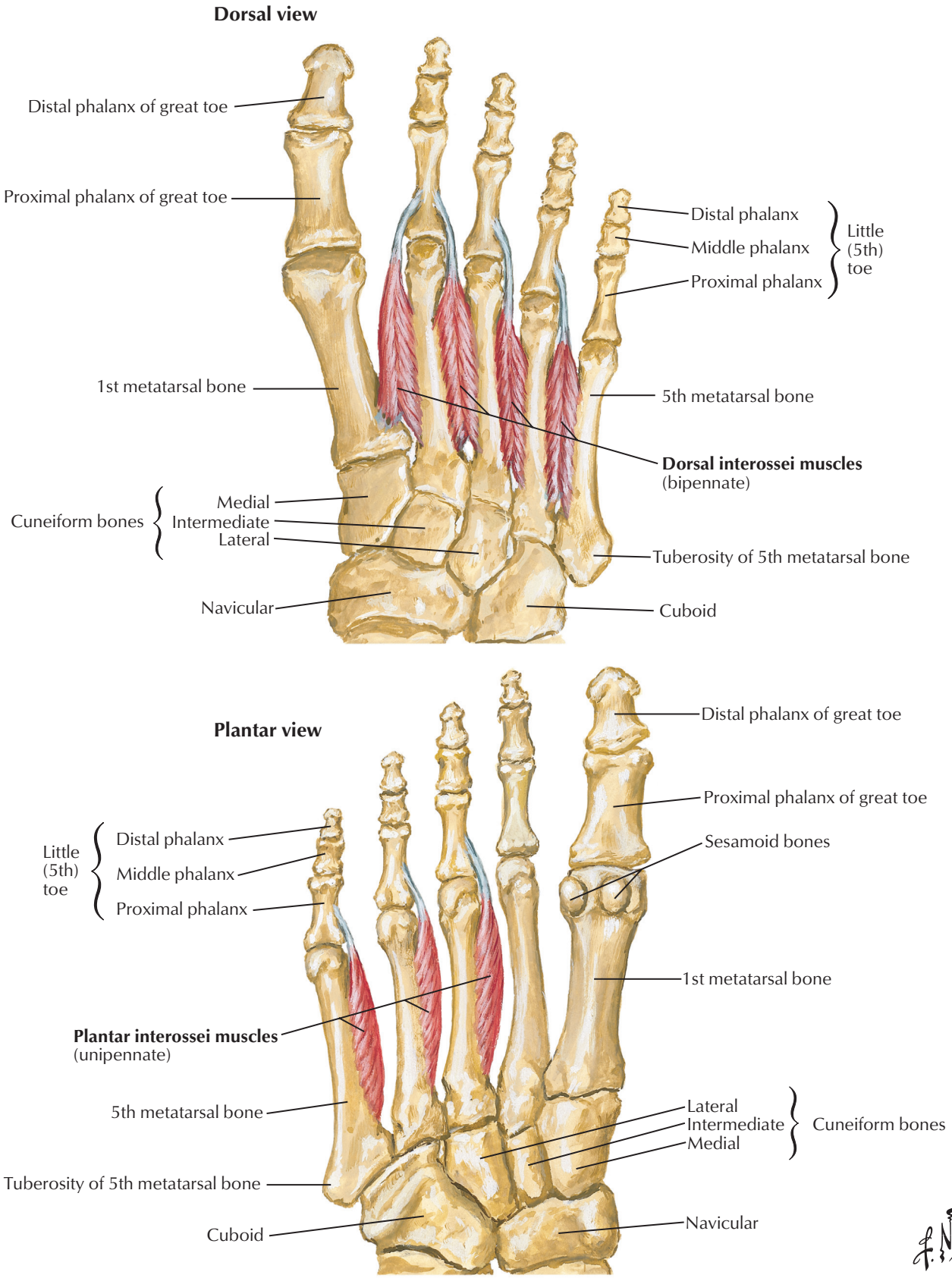
Dorsal view



Plantar view

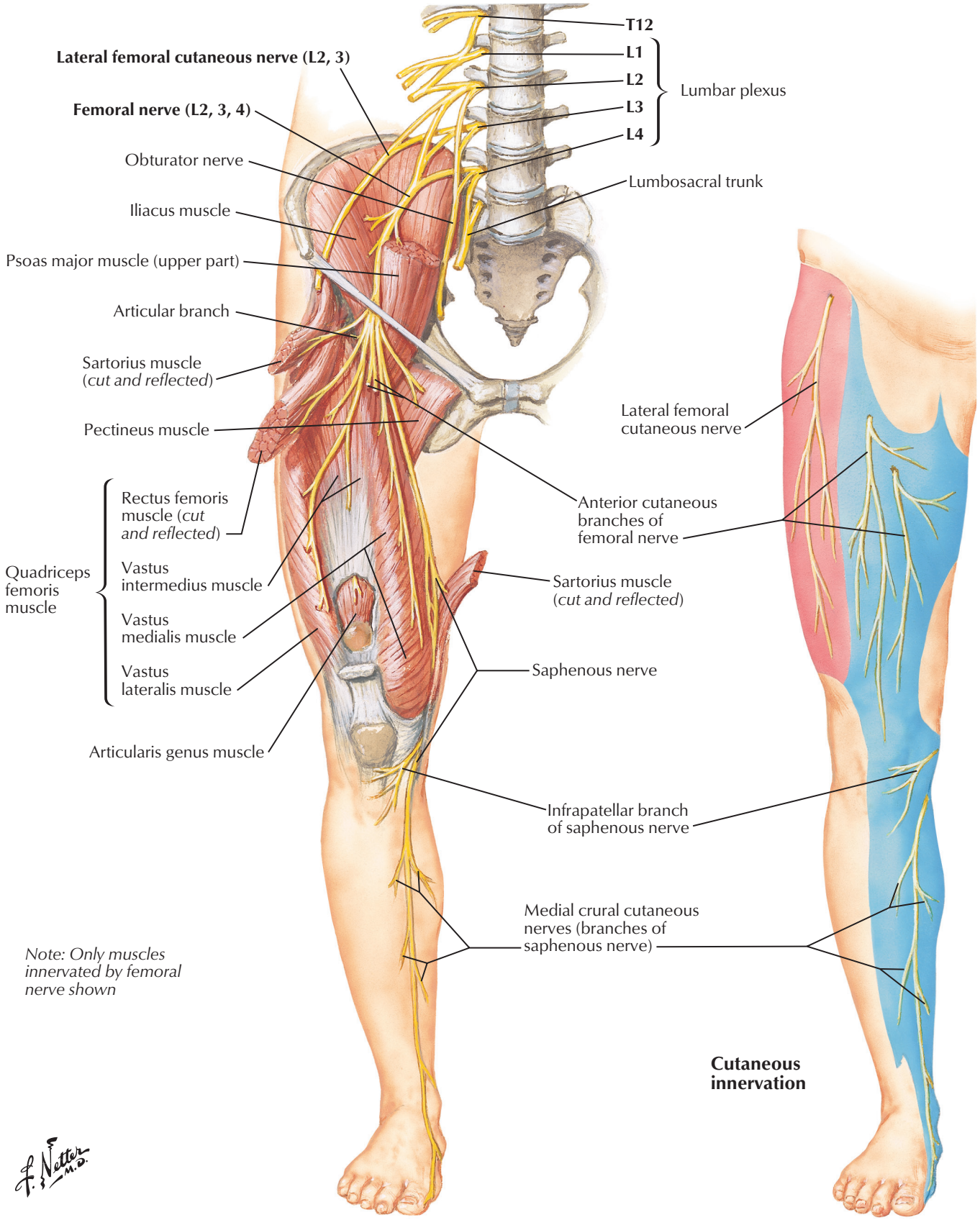


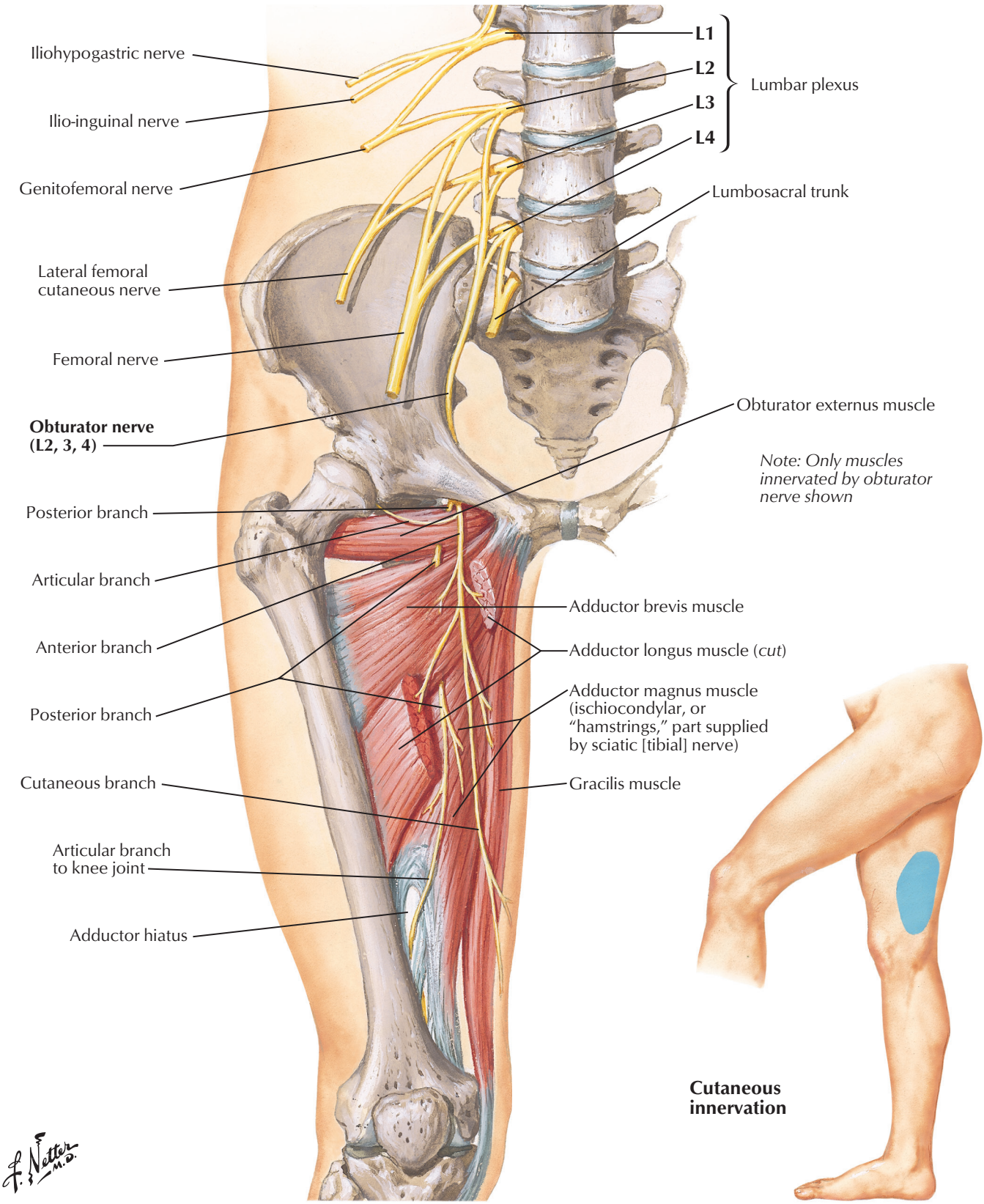
Fourth layer muscles in bold


Dorsal view
Distal phalanx of great toe
Proximal phalanx of great toe
Distal phalanx
Middle phalanx
Proximal phalanx
Little (5th) toe
1st metatarsal bone
5th metatarsal bone
Dorsal interossei muscles (bipennate)
Cuneiform bones
Medial
Intermediate
Lateral
Tuberosity of 5th metatarsal bone
Navicular
Cuboid
Plantar view
Distal phalanx of great toe
Proximal phalanx of great toe
Sesamoid bones
Little (5th) toe
Distal phalanx
Middle phalanx
Proximal phalanx
1st metatarsal bone
Plantar interossei muscles (unipennate)
5th metatarsal bone
Lateral
Intermediate
Medial
Cuneiform bones
Tuberosity of 5th metatarsal bone
Cuboid
Navicular

Femoral Nerve and Lateral Cutaneous Nerve of Thigh

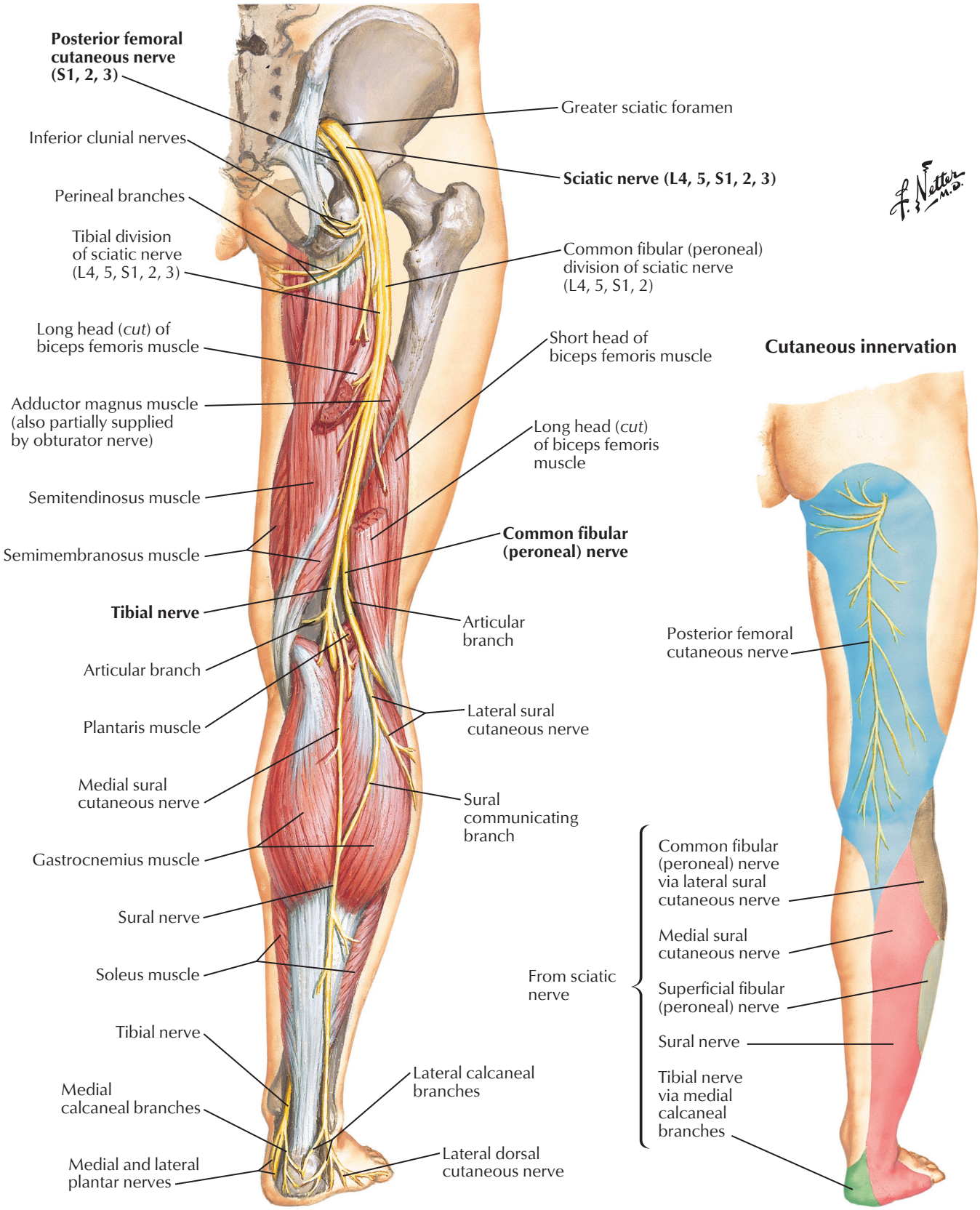
See also **Plates 262, 487, 488**

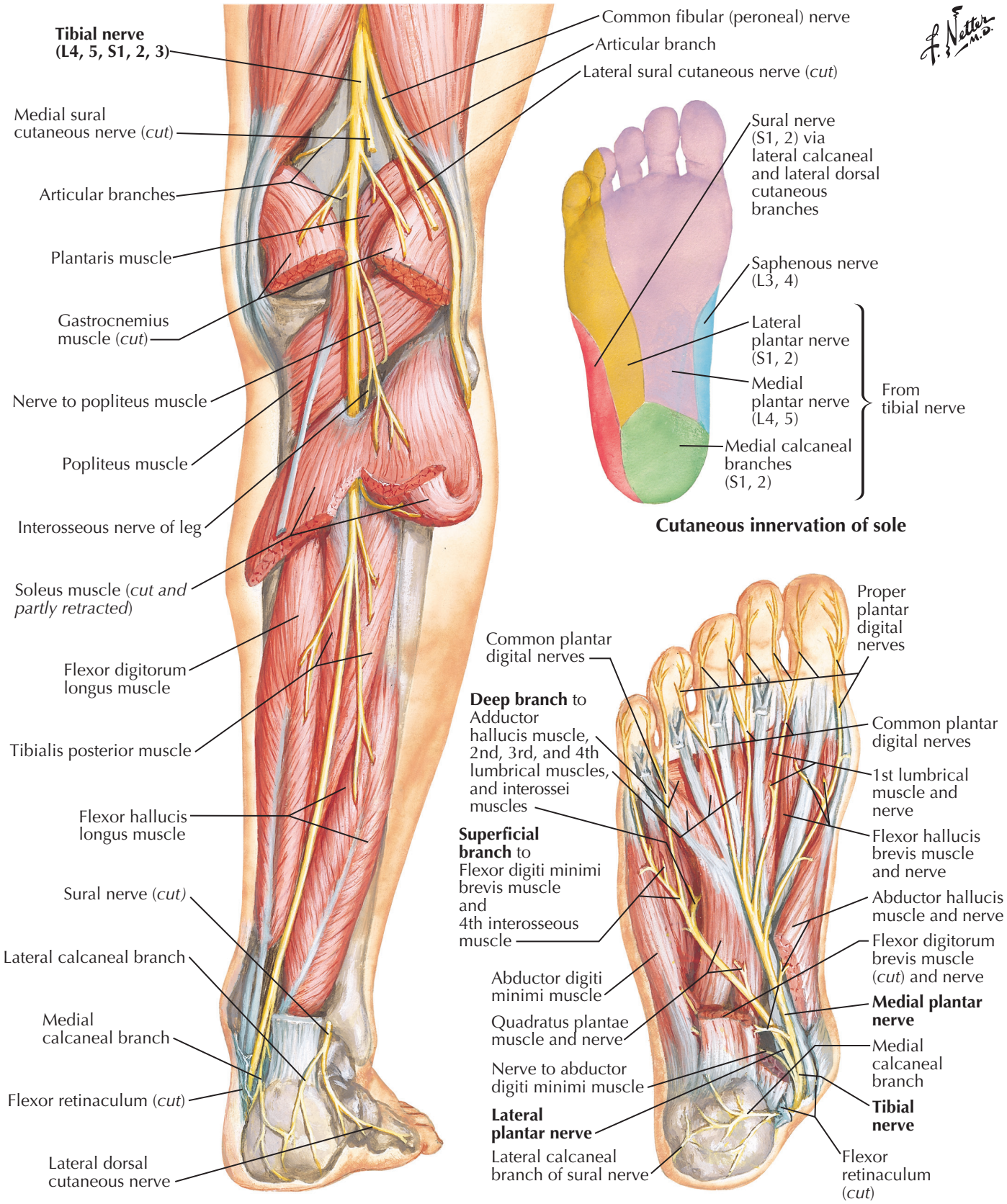



Iliohypogastric nerve
Ilio-inguinal nerve
Genitofemoral nerve
Lateral femoral cutaneous nerve
Femoral nerve
Obturator nerve (L2, 3, 4)
Posterior branch
Articular branch
Anterior branch
Posterior branch
Cutaneous branch
Articular branch to knee joint
Adductor hiatus
L1
L2
L3
L4
Lumbar plexus
Lumbosacral trunk
Obturator externus muscle
Note: Only muscles innervated by obturator nerve shown
Adductor brevis muscle
Adductor longus muscle (cut)
Adductor magnus muscle (ischiocondylar, or "hamstrings," part supplied by sciatic [tibial] nerve)
Gracilis muscle
Cutaneous innervation

Sciatic Nerve and Posterior Cutaneous Nerve of Thigh

See also Plate 489

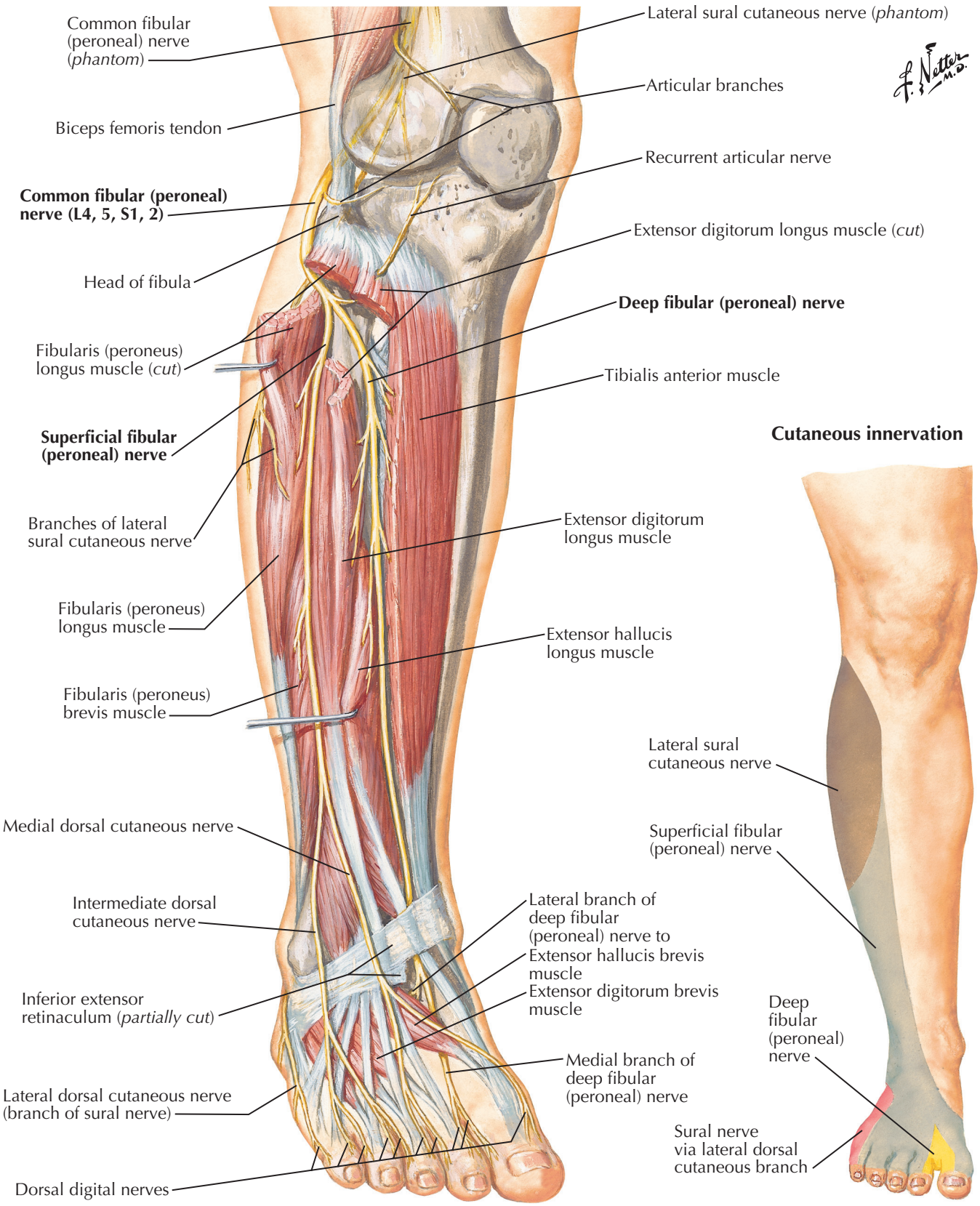




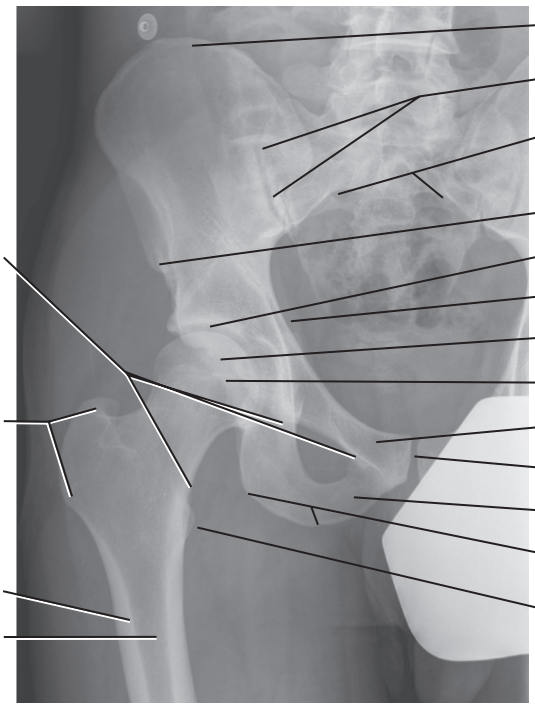
Note: Articular branches not shown

Common Fibular (Peroneal) Nerve

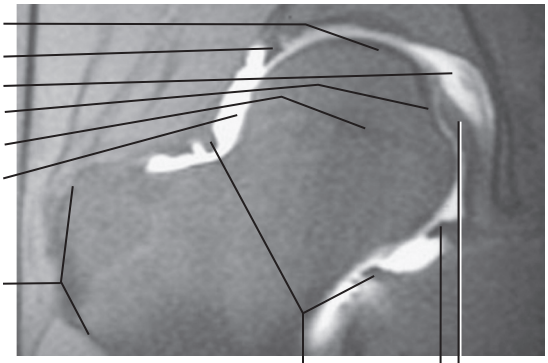
See also Plates 506, 508, 516



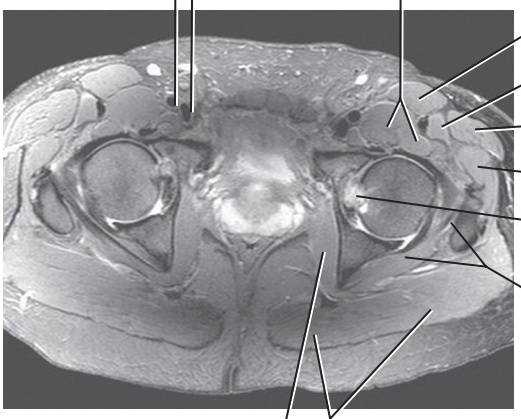
Radiograph



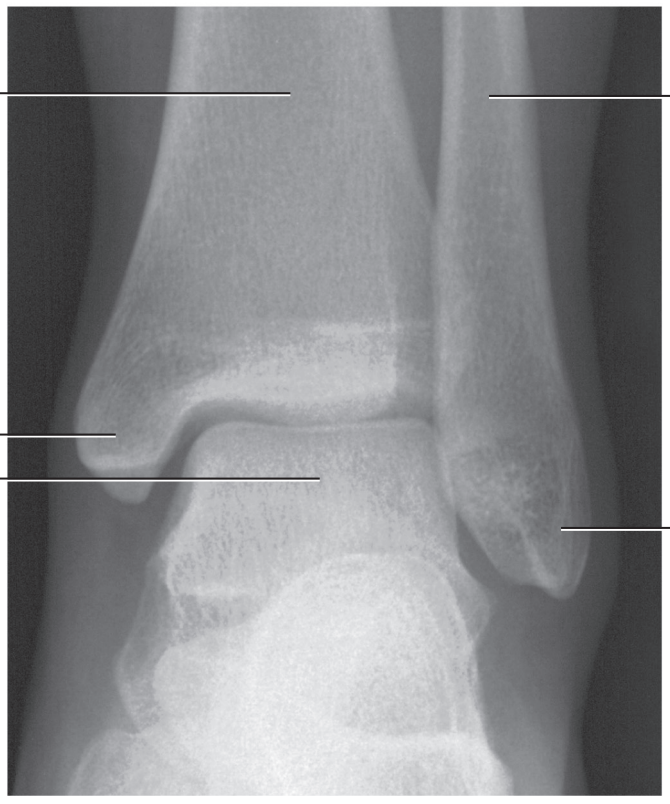
Arthrogram of hip



MRI



See also Plates 506, 513, 514



MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Abductor digiti minimi	Medial and lateral tubercles of tuberosity of calcaneus, plantar aponeurosis, and intermuscular septum	Lateral side of base of proximal phalanx of 5th digit	Lateral plantar nerve	Abducts and flexes 5th digit	Medial-lateral plantar artery, plantar metatarsal and plantar digital arteries to 5th digit	Foot
Abductor hallucis	Medial tubercle of tuberosity of calcaneus, flexor retinaculum, and plantar aponeurosis	Medial side of base of proximal phalanx of 1st digit	Medial plantar nerve	Abducts and flexes 1st digit	Medial plantar and 1st plantar metatarsal arteries	Foot
Adductor brevis	Body and inferior pubic ramus	Pectineal line and proximal part of linea aspera of femur	Obturator nerve	Adducts thigh at hip, weak hip flexor	Profunda femoris, medial circumflex femoral, and obturator arteries	Medial thigh
Adductor hallucis	*Oblique head:* bases of 2nd through 4th metatarsals *Transverse head:* ligaments of metatarsophalangeal joints of digits 3-5	Tendons of both heads lateral to side of base of proximal phalanx of 1st digit	Deep branch of lateral plantar nerve	Adducts 1st digit, maintains transverse arch of foot	Medial and lateral plantar arteries and plantar arch, plantar metatarsal arteries	Foot
Adductor longus	Body of pubis inferior to pubic crest	Middle third of linea aspera of femur	Obturator nerve (anterior division)	Adducts thigh at hip	Profunda femoris and medial circumflex femoral arteries	Medial thigh
Adductor magnus	Inferior pubic ramus, ramus of ischium *Hamstring part*: sciatic nerve (tibial division)	Gluteal tuberosity, linea aspera, medial supracondylar line *Hamstring part:* adductor tubercle of femur	*Adductor part:* obturator nerve *Hamstring part:* sciatic nerve (tibial division)	*Adductor part:* adducts and flexes thigh *Hamstring part:* extends thigh	Femoral, profunda femoris, and obturator arteries	Medial thigh
Articularis genus	Distal femur on anterior surface	Suprapatellar bursa	Femoral nerve	Pulls suprapatellar bursa superiorly with extension of knee	Femoral artery	Anterior thigh
Biceps femoris	*Long head:* ischial tuberosity *Short head:* Linea aspera and lateral supracondylar line of femur	Lateral side of head of fibula	*Long head:* sciatic nerve (tibial division) (L5–S2) *Short head:* sciatic nerve (common fibular division)	Flexes and laterally rotates leg, extends thigh at hip	Perforating branches of profunda femoris, inferior gluteal, and medial circumflex femoral arteries	Posterior thigh
Dorsal interossei (four muscles)	Adjacent sides of 1st through 5th metatarsals	*1st:* medial side of proximal phalanx of 2nd digit *2nd through 4th*: lateral sides of digits 2–4	Lateral plantar nerve	Abduct 2nd through 4th toes, flex metatarsophalangeal joints, and extend phalanges	Arcuate artery, dorsal and plantar metatarsal arteries	Foot
Extensor digitorum brevis and extensor hallucis brevis	Superolateral surface of calcaneus, lateral talocalcaneal ligament, cruciate crural ligament	First tendon into dorsal surface of base of proximal phalanx of great toe; other 3 tendons into lateral sides of tendons of extensor digitorum longus to digits 2-4	Deep fibular nerve	Aids the extensor digitorum longus in extending of 4 medial digits at the metatarsophalangeal and interphalangeal joints	Dorsalis pedis, lateral tarsal, arcuate, and fibular arteries	Anterior thigh

Variations in spinal nerve contributions to the innervation of muscles, their arterial supply, their attachments, and their actions are common themes in human anatomy. Therefore, expect differences between texts and realize that anatomical variation is normal.

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Extensor digitorum longus	Lateral condyle of tibia, proximal 3/4 of anterior surface of interosseous membrane and fibula	Middle and distal phalanges of lateral four digits	Deep fibular nerve	Extends lateral four digits and dorsiflexes foot at ankle	Anterior tibial artery	Anterior leg
Extensor hallucis longus	Middle part of anterior surface of fibula and interosseous membrane	Dorsal aspect of base of distal phalanx of great toe	Deep fibular nerve	Extends great toe, dorsiflexes foot at ankle	Anterior tibial artery	Anterior leg
Fibularis peroneus brevis	Distal 2/3 of lateral surface of fibula	Dorsal surface of tuberosity on lateral side of 5th metatarsal	Superficial fibular nerve	Everts foot and weakly plantarflexes foot at ankle	Anterior tibial and fibular arteries	Lateral leg
Fibularis peroneus longus	Head and proximal 2/3 of lateral fibula	Plantar base of 1st metatarsal and medial cuneiform	Superficial fibular nerve	Everts foot and weakly plantarflexes foot at ankle	Anterior tibial and fibular arteries	Lateral leg
Fibularis peroneus tertius	Distal third of anterior surface of fibula and interosseous membrane	Dorsum of base of 5th metatarsal	Deep fibular nerve	Dorsiflexes foot at ankle and aids in eversion of foot	Anterior tibial artery	Anterior leg
Flexor digiti minimi brevis	Base of 5th metatarsal	Lateral base of proximal phalanx of 5th digit	Superficial branch of lateral plantar nerve	Flexes proximal phalanx of 5th digit	Lateral plantar artery, plantar digital artery to 5th digit, arcuate artery	Foot
Flexor digitorum brevis	Medial tubercle of tuberosity of calcaneus, plantar aponeurosis, and intermuscular septum	Both sides of middle phalanges of lateral four digits	Medial plantar nerve	Flexes 2nd through 5th digits	Medial and lateral plantar arteries and plantar arch, plantar metatarsal and plantar digital arteries	Foot
Flexor digitorum longus	Medial part of posterior tibia inferior to soleal line	Plantar bases of distal phalanges of lateral four digits	Tibial nerve	Flexes lateral four digits and plantarflexes foot at ankle; supports longitudinal arches of foot	Posterior tibial artery	Posterior leg
Flexor hallucis brevis	Plantar surfaces of cuboid and lateral cuneiform	Both sides of base of proximal phalanx of 1st digit	Medial plantar nerve	Flexes proximal phalanx of 1st digit	Medial plantar artery, first plantar metatarsal artery	Foot
Flexor hallucis longus	Distal 2/3 of posterior fibula and interosseous membrane	Base of distal phalanx of great toe (hallux)	Tibial nerve	Flexes all joints of great toe, weakly plantarflexes foot at ankle	Fibular artery	Posterior leg
Gastrocnemius	*Lateral head:* lateral aspect of lateral condyle of femur *Medial head:* popliteal surface above medial condyle of femur	Posterior aspect of calcaneus via calcaneal tendon	Tibial nerve	Plantarflexes foot at ankle joint, assists in flexion of knee joint, raises heel during walking	Popliteal and posterior tibial arteries	Posterior leg
Gluteus maximus	Ilium posterior to posterior gluteal line, dorsal surface of sacrum and coccyx, sacrotuberous ligament	Most fibers end in iliotibial tract that inserts into lateral condyle of tibia; some fibers insert into gluteal tuberosity of femur	Inferior gluteal nerve	Extends flexed thigh, assists in lateral rotation, and abducts thigh	Inferior gluteal arteries mainly, and superior gluteal arteries occasionally	Gluteal region

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Gluteus medius	Lateral surface of ilium between anterior and posterior gluteal lines	Lateral surface of greater trochanter of femur	Superior gluteal nerve	Abducts and medially rotates thigh at hips; steadies pelvis on leg when opposite leg is raised	Superior gluteal artery	Gluteal region
Gluteus minimus	Lateral surface of ilium between anterior and inferior gluteal lines	Anterior surface of greater trochanter of femur	Superior gluteal nerve	Abducts and medially rotates thigh at hips; steadies pelvis on leg when opposite leg is raised	Main trunk and deep branch of superior gluteal artery	Gluteal region
Gracilis	Body and inferior ramus of pubis	Superior part of medial surface of tibia	Obturator nerve	Adducts thigh, flexes and medially rotates leg	Profunda femoris artery, medial circumflex femoral artery	Medial thigh
Iliacus (Iliopsoas)	Superior 2/3 of iliac fossa, iliac crest, ala of sacrum, anterior sacro-iliac ligaments	Lesser trochanter of femur and shaft inferior to it, to psoas major tendon	Femoral nerve	Flexes thigh at hips and stabilizes hip joint, acts with psoas major	Iliac branches of iliolumbar artery	Anterior thigh
Inferior gamellus	Ischial tuberosity	Medial surface of greater trochanter of femur	Nerve to quadratus femoris	Laterally rotates extended thigh at the hip	Medial circumflex femoral artery	Gluteal region
Lumbricals	Tendons of flexor digitorum longus	Medial side of dorsal digital expansions of lateral 4 digits	*Medial one:* medial plantar nerve *Lateral three*: lateral plantar nerve	Flexes proximal phalanges at MTP joint, extends phalanges at PIP and DIP joints	Lateral plantar artery and plantar metatarsal arteries	Foot
Obturator externus	Margins of obturator foramen, obturator membrane	Trochanteric fossa of femur	Obturator nerve	Laterally rotates thigh, stabilizes head of femur in acetabulum	Medial circumflex femoral artery, obturator artery	Medial thigh
Obturator internus	Pelvic surface of obturator membrane and surrounding bone	Medial surface of greater trochanter of femur	Nerve to obturator internus	Laterally rotates extended thigh, abducts flexed thigh at hip	Internal pudendal and obturator arteries	Gluteal region
Pectineus	Superior ramus of pubis	Pectineal line of femur	Femoral nerve and sometimes obturator nerve	Adducts and flexes thigh at hip	Medial circumflex femoral artery, obturator artery	Medial thigh
Piriformis	Anterior surface of sacral segments 2–4, sacrotuberous ligament	Superior border of greater trochanter of femur	Ventral rami of L5, S1, S2	Laterally rotates extended thigh, abducts flexed thigh at hip	Superior and inferior gluteal arteries, internal pudendal artery	Gluteal region
Plantar interossei (three muscles)	Bases and medial sides of 3rd through 5th metatarsals	Medial sides of bases of proximal phalanges of 3rd through 5th digits	Lateral plantar nerve	Adduct digits (2–4) and flex metatarsophalangeal joint and extend phalanges	Lateral plantar artery and plantar arch, plantar metatarsal and plantar digital arteries	Foot
Plantaris	Inferior end of lateral supracondylar line of femur and oblique popliteal ligament	Posterior aspect of calcaneus via calcaneal tendon	Tibial nerve	Weakly assists gastrocnemius	Popliteal artery	Posterior leg
Popliteus	Lateral aspect of lateral condyle of femur, lateral meniscus	Posterior tibia superior to soleal line	Tibial nerve (L4–S1)	Weakly flexes knee and unlocks it by rotating femur on fixed tibia	Inferior medial and lateral genicular arteries	Posterior leg
Psoas major (Iliopsoas)	Transverse processes of lumbar vertebrae, sides of bodies of T12–L5 vertebrae, intervening intervertebral discs	Lesser trochanter of femur	Ventral rami of first lumbar nerve	Acting superiorly with iliacus, flexes hip; acting inferiorly, flexes vertebral column laterally; used to balance trunk in sitting position; acting inferiorly with iliacus, flexes trunk	Lumbar branches of iliolumbar artery	Anterior thigh
Quadratus femoris	Lateral margin of ischial tuberosity	Quadrate tubercle on intertrochanteric crest of femur	Nerve to quadratus femoris	Laterally rotates thigh at hip	Medial circumflex femoral artery	Gluteal region

MUSCLE	PROXIMAL ATTACHMENT (ORIGIN)	DISTAL ATTACHMENT (INSERTION)	INNERVATION	MAIN ACTIONS	BLOOD SUPPLY	MUSCLE GROUP
Quadratus plantae	Medial and lateral sides of plantar surface of calcaneus	Posterolateral edge of flexor digitorum longus tendon	Lateral plantar nerve	Corrects for oblique pull of flexor digitorum longus tendon, thus assists in flexion of toes	Medial and lateral plantar arteries and deep plantar arterial arch	Foot
Rectus femoris (quadriceps)	Anterior inferior iliac spine and ilium superior to acetabulum	Base of patella and to tibial tuberosity via patellar ligament	Femoral nerve	Extends leg at knee joint and flexes thigh at hip joint	Profunda femoris and lateral circumflex femoral arteries	Anterior thigh
Sartorius	Anterior superior iliac spine and superior part of notch below it	Superior part of medial surface of tibia	Femoral nerve	Abducts, laterally rotates, and flexes thigh; flexes knee joint	Femoral artery	Anterior thigh
Semimembranosus	Ischial tuberosity	Posterior part of medial condyle of tibia	Sciatic nerve (tibial division)	Flexes leg, extends thigh	Perforating branch of profunda femoris and medial circumflex femoral arteries	Posterior thigh
Semitendinosus	Ischial tuberosity	Superior part of medial surface of tibia	Sciatic nerve (tibial division)	Flexes leg, extends thigh	Perforating branch of profunda femoris and medial circumflex femoral arteries	Posterior thigh
Soleus	Posterior aspect of head of fibula, proximal 1/4 of posterior surface of fibula, soleal line of tibia	Posterior aspect of calcaneus via calcaneal tendon	Tibial nerve	Plantarflexes foot at ankle, stabilizes leg over foot	Popliteal, posterior tibial, and fibular arteries	Posterior leg
Superior gemellus	Outer surface of ischial spine	Medial surface of greater trochanter of femur	Nerve to obturator internus	Laterally rotates extended thigh at the hip	Inferior gluteal and internal pudendal arteries	Gluteal region
Tensor fasciae latae	Anterior superior iliac spine and anterior part of iliac crest	Iliotibial tract that attaches to lateral condyle of tibia	Superior gluteal nerve	Abducts, medially rotates, and flexes thigh at hip; helps to keep knee extended	Ascending branch of lateral circumflex femoral artery	Gluteal region
Tibialis anterior	Lateral condyle, proximal half of lateral tibia, interosseous membrane	Medial plantar surfaces of medial cuneiform and base of 1st metatarsal	Deep fibular nerve	Dorsiflexes foot at ankle and inverts foot	Anterior tibial artery	Anterior leg
Tibialis posterior	Posterior tibia below soleal line, interosseous membrane, proximal half of posterior fibula	Tuberosity of navicular bone, all cuneiforms, cuboid, and bases of 2nd through 4th metatarsals	Tibial nerve	Plantarflexes foot at ankle and inverts foot	Fibular artery	Posterior leg
Vastus intermedius (quadriceps)	Anterior and lateral surfaces of body of femur	Base of patella and to tibial tuberosity via patellar ligament	Femoral nerve	Extends leg at knee joint	Lateral circumflex femoral and profunda femoris arteries	Anterior thigh
Vastus lateralis (quadriceps)	Greater trochanter, lateral lip of linea aspera of femur	Base of patella and to tibial tuberosity via patellar ligament	Femoral nerve	Extends leg at knee joint	Lateral circumflex femoral and profunda femoris arteries	Anterior thigh
Vastus medialis (quadriceps)	Intertrochanteric line, medial lip of linea aspera of femur	Base of patella and to tibial tuberosity via patellar ligament	Femoral nerve	Extends leg at knee joint	Femoral and profunda femoris arteries	Anterior thigh

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1 Head and Neck Study Guide

1.1 TOPOGRAPHIC SURFACE ANATOMY

Study Aims

At the end of your study, you should be able to:

- Identify the key landmarks in the midline of the neck and their significance
- State the structures that are situated at the level of C6
- Outline the boundaries of the triangles of the neck
- Describe the landmarks for palpation of the main arteries, which can be palpated in the face and neck
- Identify prominent features of the face

GUIDE

KEY LANDMARKS OF MIDLINE OF THE NECK

A number of landmarks visible on the body's surface correspond to deeper structures.

- Hyoid bone
  - Lies at level of C3 vertebra
  - U-shaped bone
  - Does not articulate with any other bone
  - Is suspended by muscles from
    - Mandible
    - Styloid processes of temporal bones
    - Thyroid cartilage
    - Manubrium of sternum
    - Scapulae
- Thyroid cartilage
  - Formed from anterior, midline fusion of two laminar plates = laryngeal prominence (Adam's apple)
  - Laminae diverge superiorly
    - Form V-shaped thyroid notch
    - Lie at the level of C4 vertebra
- C4 vertebral level
  - Bifurcation of common carotid artery into external and internal carotid arteries
  - Site of carotid sinus (baroreceptor) and carotid body (chemoreceptor)
- Carotid pulse can be palpated at anterior border sternocleidomastoid (level of C5 vertebra).
- Cricoid cartilage
  - Only complete ring cartilage in respiratory tract
  - Shaped like signet ring with band anteriorly
  - Lower border corresponds to level of C6 vertebra.
- C6 vertebral level
  - Junction of larynx and trachea
  - Junction of pharynx and esophagus
  - Level at which inferior and middle thyroid arteries enter the thyroid gland
  - Vertebral artery (first branch subclavian artery) enters foramen transversarium of C6 transverse process to ascend to brain through successively higher foramina.
  - Superior belly of omohyoid muscle crosses carotid sheath.
  - Level of middle cervical sympathetic ganglion
  - Carotid artery can be compressed and palpated against transverse process C6.
- Isthmus of thyroid gland overlies second and third tracheal cartilages.
- Jugular (suprasternal) notch
  - Concave center of superior border of manubrium
  - Between medial ends of clavicles

OTHER LANDMARKS OF THE NECK

- Platysma
  - Thin, broad sheet of muscle within superficial fascia of the neck
  - Muscle of facial expression, tensing the skin
  - Draws corners of mouth down, as in a grimace, and depresses mandible
- External jugular vein
  - Deep to platysma, descends from angle to mandible to midpoint of clavicle
  - Useful for assessment of venous filling with patient sitting at 45 degrees
- Sternocleidomastoid (SCM)
  - Key landmark of neck
  - Divides neck into anterior and posterior triangles *(see Section 1.4, Head and Neck—Neck)*
  - Sternal head attaches to manubrium of sternum.
  - Clavicular head attaches to superior middle third of clavicle.
  - Can be seen and palpated when acting unilaterally to flex and rotate head and neck to one side, so that ear approaches shoulder and chin turns in the opposite direction

LANDMARKS OF THE FACE

- Glabella
  - Smooth midline prominence on the frontal bone
  - Located above the root of the nose, between supraorbital margins
- Zygomatic arch
  - Forms prominence of cheek
  - Can palpate superficial temporal artery at lateral end
  - Prone to fractures in facial trauma
- Mastoid process
  - Bony prominence behind external acoustic meatus
  - Site of proximal attachment sternocleidomastoid muscle
- Inion—prominent point of external occipital protuberance at back of head
- Auricle—part of external ear
  - Skin-covered cartilage, except for lobule
  - Features include: pinna; tragus; antitragus and helix
- External nose
  - Skeleton mainly cartilaginous
  - Dorsum extends from root to apex
  - Inferior surface has two openings or nares (nostrils)
    - Bounded laterally by alae of nose
    - Separated by skin over nasal septum
- Philtrum—midline infranasal depression of upper lip
- Masseter muscle
  - Felt over ramus of mandible when teeth are clenched
  - Parotid duct can be palpated at medial border (duct opens over second molar inside cheek).
- Temporalis muscle can be felt above zygomatic arch when teeth clenched.
- Facial artery can be palpated over lower margin body of mandible in line with a point one fingerbreadth lateral to the angle of the mouth.

CLINICAL POINTS

TRACHEOSTOMY

- Transverse incision through skin of neck and anterior wall of trachea
- Method for achieving a definitive airway
- Transverse incision made through skin, at midpoint between suprasternal notch and thyroid cartilage
- Platysma and pretracheal fascia divided
- Strap muscles retracted
- Thyroid isthmus divided or retracted
- Opening made between first and second tracheal rings or through second through fourth tracheal rings
- Tracheostomy tube inserted

NEEDLE CRICOTHYROTOMY

- Done in extreme emergency
- Performed if proximal airway is obstructed to temporarily oxygenate the patient
- Large-bore needle inserted into the cricothyroid membrane and connected to an oxygen supply

CENTRAL VENOUS LINE

- Large veins such as the subclavian have relatively constant relationships to easily identifiable anatomical landmarks.
- Placement of large-bore venous catheter in an emergent situation to deliver high flow of fluid or blood products
- Used for administration of chemotherapeutic agents, hyperalimentation fluids, and so on
- Used for assessing right heart (venous) pressures
- Vein located in an area bounded by the sternal and clavicular attachments of sternocleidomastoid and the clavicle—just deep to middle third of clavicle
- Subclavian vein is inferior and anterior to subclavian artery and separated from it by anterior scalene muscle.

1.2 BONES AND LIGAMENTS

Study Aims

At the end of your study, you should be able to:

- Describe the anatomical division of the head into a neurocranium and viscerocranium
- Describe the function of the neurocranium and viscerocranium
- Outline the bones that form the neurocranium
- Know the major sutures of the skull
- Describe the division of the base of skull into anterior, middle, and posterior cranial fossae and the contents of each
- List the foramina and key structures that pass through them
- Identify the prominent features of the mandible
- Describe the structure of the temporomandibular joint and the ligaments that stabilize it

GUIDE

BONES OF HEAD AND NECK

- Skull
- Mandible
- Cervical vertebrae

Skull

The skull is divided into the neurocranium or calvaria (contains the brain and its meningeal coverings) and the viscerocranium (facial skeleton). The skull is composed of 22 bones (excluding the middle ear ossicles), with 8 forming the cranium and 14 forming the face. The orbits (eye sockets) lie between the calvaria (skull cap) and the facial skeleton and are formed by contributions from 7 different bones.

Neurocranium		Viscerocranium	
Ethmoidal	1	Zygomatic	2
Frontal	1	Vomer	1
Occipital	1	Inferior nasal concha	2
Sphenoidal	1	Maxilla	2
Parietal	2	Nasal	2
Temporal	2	Palatine	2
		Lacrimal	2
		(Mandible)	1
N = 22	8	+	14

- Function of skull
  - Encloses, supports, and protects brain and meninges
  - Contains foramina for transmission of nerves and vessels
  - Forms foundation for face
  - Contains specialized cavities and openings for sense organs (e.g., nasal, oral)
- Neurocranium
  - Cranial vault and base of skull
  - Encloses and protects brain
  - Composed of 8 bones
  - Bones united by interlocking sutures
  - Can be divided
    - Calvaria—domelike roof
    - Cranial base
  - Calvaria composed of 4 bones
    - Frontal bone anteriorly
    - Occipital bone posteriorly
    - Two parietal bones laterally
  - Cranial base formed from
    - Ethmoidal bone
    - Parts of occipital and temporal bones
- Viscerocranium
  - = Facial skeleton
  - Composed of 14 bones
  - Encloses orbits, nose, paranasal sinuses, mouth, and pharynx
  - Maxillae and mandible form upper and lower jaw, respectively, and house the teeth
- Three auditory ossicles
  - Malleus, incus, and stapes
  - Found spanning tympanic cavity
  - First bones to be completely ossified during development

Major Sutures of the Skull. Most bones of the skull are bound by sutures, a type of fibrous joint that fuses with age and becomes immobile.

- Coronal suture separates frontal and parietal bones.
- Sagittal suture separates two parietal bones.
- Lambdoid suture separates parietal and temporal bones from occipital bones.
- Squamous suture separates squamous part of temporal bone from parietal bone.
- Sphenosquamous suture separates squamous part of temporal bone from greater wing of sphenoidal bone.
- Metopic suture between two frontal bones is largely obliterated with fusion of frontal bones

Internal Features of Base of Skull.

- Divided into anterior, middle, and posterior cranial fossae
- Anterior cranial fossa
  - Contains frontal lobe of brain
  - Formed by frontal bone anteriorly, ethmoidal bone medially, and lesser wing of sphenoidal bone posteriorly
  - Features
    - Frontal crest—midline bony extension of frontal bone
    - Foramen cecum—foramen at base of frontal crest
    - Crista galli—midline ridge of bone from ethmoid posterior to foramen cecum
    - Cribriform plate—thin, sievelike plate of bone on either side of crista galli, which transmits olfactory nerves from nasal cavity to olfactory bulbs
- Middle cranial fossa
  - Contains temporal lobe, hypothalamus, and pituitary gland
  - Formed by greater wing and body of sphenoidal bone, petrous temporal bone, lesser wing of sphenoidal bone
  - Features
    - Sella turcica—central depression in body of sphenoidal bone for pituitary gland
    - Tuberculum sellae—swelling anterior to sella turcica
    - Dorsum sellae—crest on body of sphenoidal bone posterior to sella turcica
    - Anterior clinoid processes—medial projections of lesser wings of sphenoidal bones
    - Posterior clinoid processes—swelling at either end of dorsum sellae
    - Foramen lacerum (one on each side)—jagged opening closed by plate of cartilage in life, transmits nothing
  - Contains four foramina in a crescent on either side in the body of the sphenoidal bone
    - Superior orbital fissure
    - Foramen rotundum
    - Foramen ovale
    - Foramen spinosum
- Posterior cranial fossa
  - Contains cerebellum, pons, and medulla oblongata
  - Composed largely of occipital bone, body of sphenoidal bone, petrous, and mastoid parts of temporal bone
  - Features
    - Foramen magnum—transmits spinal cord
    - Internal occipital crest—divides posterior fossa into two lateral cerebellar fossae
    - Grooves for transverse and sigmoid dural venous sinuses
    - Jugular foramen—transmits sigmoid sinus (internal jugular vein) and several cranial nerves
    - Internal acoustic meatus—anterior and superior to jugular foramen, transmits facial and vestibulocochlear nerves (CN VII and CN VIII)
    - Hypoglossal canal—anterolateral and superior to foramen magnum, transmits hypoglossal nerve (CN XII)

Foramina of Skull. Numerous holes appear in the cranial floor, and they are called foramina. Important structures, especially cranial nerves arising from the brain, pass through the foramen to access the exterior.

Foramen/Opening	Bone	Structures Transmitted
Optic canal	Lesser wing of sphenoidal bone	Optic nerve Ophthalmic artery Sympathetic plexus
Superior orbital fissure	Greater and lesser wings of sphenoidal bone	Lacrimal nerve (V_1) Frontal nerve (V_1) Trochlear nerve (IV) Oculomotor nerve (III) Abducent nerve (VI) Nasociliary nerve (V_1) Superior ophthalmic vein
Inferior orbital fissure	Between greater wing of sphenoidal bone and zygomatic	Infra-orbital vein Infra-orbital artery Infra-orbital nerve
Foramen spinosum	Greater wing of sphenoidal bone	Middle meningeal artery and vein
Foramen rotundum	Greater wing of sphenoidal bone	Maxillary division trigeminal nerve (V_3)
Foramen ovale	Greater wing of sphenoidal bone	Mandibular division trigeminal nerve Lesser petrosal nerve
Foramen lacerum	Between temporal bone (petrous area) and sphenoidal bone	Internal carotid artery
Foramen magnum	Occipital bone	Medulla oblongata Vertebral artery Meninges Spinal roots of accessory nerve
Hypoglossal canal	Occipital bone	Hypoglossal nerve (XII)
Jugular foramen	Between temporal bone (petrous area) and occipital bone	Glossopharyngeal nerve (IX) Vagus nerve (X) Accessory nerve (XI) Inferior petrosal sinus Sigmoid sinus Posterior meningeal artery

Mandible

- Unpaired bone of lower jaw
- Largest and strongest bone in face
- Articulates with temporal bone at temporomandibular joint
- Consists of
  - Body
    - Can be divided into lower base and upper alveolar part
    - Has mental protuberance anteriorly and inferiorly where two sides come together
    - Mental spine: rough projection on inner surface of body in midline
    - Mental foramen below second premolar transmits terminal branch of inferior alveolar nerve to supply skin and mucus membrane of lower lip and chin.
    - Mylohyoid line: ridge extending upward and backward on internal surface of alveolar part of mandible for attachment mylohyoid muscle
    - Submandibular fossa: long depression below mylohyoid line, which accommodates submandibular gland
    - Sublingual fossa: concavities on either side of mental spine for sublingual gland
  - Rami
    - Lateral vertical projections from body
    - Each meets body inferiorly at angle of jaw.
    - Two processes at superior end: coronoid process and condylar process
    - Coronoid process—attachment of temporalis muscle
    - Condylar process—part of temporomandibular joint
    - Mandibular notch—concavity between condylar and coronoid processes
    - Mandibular foramen: on inner surface of ramus; entrance to mandibular canal, through which passes the inferior alveolar nerve
    - Lingula—thin projection of bone overlapping mandibular foramen
    - Mylohyoid groove—groove leading anteriorly and inferiorly from mandibular foramen indicating course of mylohyoid nerve and vessels

Temporomandibular Joint

The mandible articulates with the temporal bone, and in chewing and speaking it is only the mandible or lower jaw that moves; the upper jaw or maxilla remains stationary. The teeth are contained in the alveolar portion of the mandible.

- Articulation between condylar process of mandible, articular tubercle of temporal bone, and mandibular fossa
- Modified hinge-type synovial joint
- Contains fibrocartilaginous disc, which divides joint cavity into two compartments
  - Gliding movements (protrusion and retrusion/retraction) occur in upper compartment.
  - Hinge movements (depression and elevation) occur in lower compartment.

- Stabilized by three ligaments
  - Lateral temporomandibular ligament
    - Lateral thickened parts of articular capsule
    - Prevent posterior dislocation of joint
  - Sphenomandibular ligament
    - Primary passive support
    - Runs from spine of sphenoid to lingual of mandible
    - Serves as swinging hinge and check ligament
  - Stylomandibular ligament
    - Thickening in capsule of parotid gland
    - Runs from styloid process to angle of mandible
- Movements
  - Depression—suprahyoid and infrahyoid muscles, gravity
  - Elevation—temporalis, masseter, and medial pterygoid muscles
  - Protrusion—lateral pterygoid, masseter, and medial pterygoid muscles
  - Retraction/retraction—temporalis, masseter muscles
  - Side to side grinding—retractors of same side, protruders of opposite side

Cervical Vertebrae

See Section 2.2, Bones and Ligaments

ANATOMICAL POINTS

- A newborn's skull is large compared with other parts of the skeleton.
- Facial skeleton is small compared to calvaria.
- Two halves of mandible begin to fuse during first year.
- The mastoid process is not present at birth but develops in the first 2 years of life.
- The anterior fontanelle
  - Diamond-shaped region covered by a fibrous membrane
  - Lies at juncture of both frontal with both parietal bones
  - Ossifies by 18 months
  - Useful for assessing hydration and measuring heart rate and intracranial pressure
  - Enlargement of frontal and facial regions associated with increasing size of paranasal sinuses
  - Vertical growth of face because of dental development
- Thinnest part of skull is pterion.
  - Where parietal bone articulates with greater wing of sphenoidal bone
  - Fractures can cause intracranial bleeding, as pterion overlies anterior division of middle meningeal artery and vein.

CLINICAL POINTS

SKULL (CALVARIA) FRACTURES

- Can occur as result of direct trauma to head
- Can be one of several types
  - Depressed
    - Produced by hard blows in regions where calvaria is thin
    - Fragment of bone forced inward into brain
  - Linear
    - Most frequent
    - Fracture lines radiate away from point of impact.
  - Comminuted—bone broken into several pieces
  - Contre-coup
    - May be no fracture at impact site
    - Brain impacts opposite side of skull and rebounds to site of impact, with resulting bruising.
- May be associated with brain injury
  - When assessing a patient with a head injury, the Glasgow Coma Scale (GCS) is useful.

LE FORT FRACTURES

Common variants of fractures of the maxillae, naso-orbital complex, and zygomatic bones (midface fractures) were classified by Le Fort (surgeon and gynecologist)

- Le Fort I
  - Horizontal fracture of one or both maxillae at level of the nasal floor
  - May present with crepitus on palpation and epistaxis
  - Rarely compromises airway
- Le Fort II
  - Pyramidal-shaped fracture that includes horizontal fracture of both maxillae, extending superiorly through maxillary sinuses, infra-orbital foramina, and ethmoids to bridge of nose
  - Separates central face from rest of skill
  - Places the airway at risk
- Le Fort III
  - Includes fractures of Le Fort II plus horizontal fracture through superior orbital fissures, ethmoidal and nasal bones, great wings of sphenoidal bones, and zygomatic bones
  - Maxillae and zygomatic bones separate from skull.
  - May cause airway problems, nasolacrimal apparatus obstruction, and cerebrospinal fluid (CSF) leakage

MEMORY AIDS

Cranial/ Orbital Bones: **O**ccipital, **P**arietal, **F**rontal, **T**emporal, **E**thmoidal, **S**phenoidal
Old **P**eople **F**rom **T**exas **E**at **S**piders

Cranial Sutures: Sutures have **CLASS**
C **C**oronal
L **L**ambdoid
A **A**nd
S **S**quamous
S **S**agittal

"Con Man Facial Bones: Max and Pal Ziggy Lack Nasty Voices"
Con = Conchae
Man = Mandible
Max = Maxilla
Pal = Palatine
Ziggy = Zygomatic
Lack = Lacrimal
Nasty = Nasal
Voices = Vomer

Fontanels ***(Infant Skull)***: A baby's first words might be **"PAPA!"**
P **P**osterior
A **A**nterior

P **P**osterolateral
A **A**nterolateral

1.3 SUPERFICIAL FACE

Study Aims

At the end of your study, you should be able to:

- Outline the main muscles of facial expression and their actions
- Know the layers of the scalp, its innervation, and vascular supply
- Understand the vascular supply and lymphatic drainage of the face
- Know the sensory and motor innervation of the face
- Outline the main muscles of mastication and their actions

GUIDE

FACE

- Subcutaneous tissue of face
  - Contains muscles of facial expression
  - Contains varying amount of fat—for example, buccal fat pads of cheek
  - Highly vascular
  - Contains sensory branches of trigeminal (V) nerve, upper cervical spinal nerves and motor branches of facial nerve (VII)
  - Traversed by skin ligaments (retinacula cutis)
    - Bands of connective tissue
    - Connect skin to bones
- Muscles of facial expression: The muscles of facial expression are in several ways unique among the skeletal muscles of the body. They all originate embryologically from the second pharyngeal arch and are all innervated by terminal branches of the facial nerve (cranial nerve [CN] VII). Additionally, most arise from the bones of the face or fascia and insert into the dermis of the skin overlying the scalp, face, and anterolateral neck.
  - Lie within superficial fascia
  - Most arise from bone and insert into skin.
  - Arranged as sphincters or dilators around orifices of face
  - Innervated by one of five main branches of facial nerve (occipitalis innervated by posterior auricular branch)
- Muscles related to the orbit
  - Orbicularis oculi
    - Composed of three parts: lacrimal, palpebral, orbital
    - Lacrimal part draws eyelids and lacrimal puncta medially to drain tears.
    - Inner palpebral part gently closes eyelids (blinking).
    - Outer orbital part that tightly closes eyelids (squinting).
  - Corrugator supercilii
    - Draws medial end of eyebrow medially and inferiorly for a concerned look
    - Wrinkles skin of forehead
  - Frontalis portion of occipitofrontalis
    - Elevates eyebrows for surprised look
    - Wrinkles forehead
- Muscles related to the nose
  - Nasalis
    - Compressor naris—compresses nostril
    - Dilator naris—flares nostrils
  - Procerus
    - From forehead over bridge of nose
    - Draws medial eyebrow inferiorly
    - Creates transverse wrinkles over nose—frowning
- Muscles related to the ear
  - Anterior, superior, and posterior auricular
  - Variably developed
- Muscles related to mouth and lips
  - Orbicularis oris
    - Sphincter of mouth
    - Important for speech, holding food between teeth, whistling, blowing
  - Levator labii superioris alaeque nasi
    - Elevates nose and upper lip
  - Mentalis
    - Wrinkles skin on chin
  - Buccinator
    - Involved in smiling
    - Holds food between teeth during chewing
    - Used in whistling, sucking, and horn blowing
  - Depressor anguli oris
    - Depresses angle of mouth
  - Levator anguli oris
    - Elevates corner of mouth
  - Levator labii superioris
    - Lifts and everts upper lip
  - Depressor labii inferioris
    - Draws lip down and laterally
    - Used to show impatience
  - Risorius
    - Draws corner of mouth laterally
    - Used in grinning
  - Zygomaticus major
    - Draws angle of mouth up and laterally
    - Used in smiling and laughing
  - Zygomaticus minor
    - Raises upper lip as when showing contempt
  - Platysma
    - Depresses mandible
    - Draws corners of mouth down
    - Used when grimacing

SCALP

- Extends from superior nuchal line to superior orbital ridge
- Laterally extends to external acoustic meatus and zygomatic arch
- Composed of five layers
  - First three are adherent to skull, move as one.
  - Skin (1)
    - Contains sweat and sebaceous glands and hair follicles
    - Well vascularized
  - Connective tissue (2)
    - Dense
    - Well vascularized and innervated

  - Aponeurosis of occipitofrontalis muscle (3)
    - Tendinous sheet
    - Connects occipitalis, frontalis, and superior auricular muscles
  - Loose connective tissue (4)
    - Spongy
    - Layer that collects fluid from injury of infection
    - Moves freely with first three layers over pericranium
  - Periosteum of skull (5)
    - External periosteum of calvaria
    - Fairly firmly attached to bone
    - Most tightly bound at suture lines
- Vasculature of scalp
  - Scalp has rich blood supply, so bleeding from a scalp injury is profuse.
  - Arteries anastomoses
  - Branches of external carotid artery to scalp
    - Posterior auricular
    - Occipital
    - Superficial temporal
  - Branches of internal carotid artery to scalp
    - Supratrochlear artery
    - Supra-orbital artery
  - Venous drainage of scalp occurs via veins of same name accompanying arteries.
  - Deep aspects of scalp drain to deep temporal veins to pterygoid venous plexus.
- Innervation of scalp
  - Anterior to auricle: ophthalmic, maxillary, and mandibular divisions of cranial nerve (CN) V (trigeminal)
  - Posterior to auricle: cutaneous branches from C2 and C3 spinal nerves

Vascular Supply of the Face

Arteries.

- Facial artery
  - Major arterial source for face
  - Arises from external carotid artery, crosses mandible, and traverses face to medial angle of eye
  - Branches to upper and lower lip and nose
- Superficial temporal artery
  - Terminal branch of external carotid
  - Enters temporal fossa and ends in scalp
- Transverse facial artery
  - From superficial temporal
  - Crosses face below zygomatic arch

Veins.

- Supratrochlear vein
  - Descends from forehead to nose
  - Joins supra-orbital to form angular vein
- Supra-orbital vein
  - Begins in forehead and passes medially to join supratrochlear vein
  - Sends branch through supra-orbital notch to joint superior ophthalmic vein
- Facial vein
  - Two veins provide main venous drainage of face.
  - Follow course of facial artery
  - Drain directly or indirectly into internal jugular vein
  - Communicates with pterygoid venous plexus and cavernous sinus via superior ophthalmic vein
- Superficial temporal vein
  - Drains scalp and forehead
  - Unites with maxillary vein to form retromandibular vein
- Retromandibular vein
  - Descends through parotid gland
  - Sends branch to facial vein
  - Joins posterior auricular vein to form external jugular vein

Lymphatic Drainage of the Face

- Superficial lymphatics travel with veins
- Deep lymphatics travel with arteries
- Lateral face → parotid lymph nodes
- Upper lip and lateral lower lip → submandibular lymph nodes
- Chin and central part of lower lip → submental lymph nodes
- All lymphatic drainage eventually reaches deep cervical lymph nodes

Innervation of the Face

- Cutaneous branches of cervical nerves
  - From cervical plexus
  - Innervate posterior neck, ear, and area over parotid gland
- Trigeminal nerve (CN V)
  - Sensory for the face
  - Motor for muscles of mastication
  - Branches of ophthalmic nerve—CN V_1
    - Nasociliary nerve → external nasal nerve to skin on dorsum of nose
    - Nasociliary nerve → infratrochlear nerve to skin and lower eyelid
    - Frontal nerve → supratrochlear nerve to skin in mid forehead
    - Frontal nerve → supra-orbital nerve to skin of forehead and upper eyelid
  - Branches of maxillary nerve—CN V_2
    - Infra-orbital nerve to skin of cheek, lower lid, lateral nose and mouth, upper lip
    - Zygomaticotemporal nerve to skin over anterior temple
    - Zygomaticofacial nerve to skin over zygomatic arch
  - Branches of mandibular nerve—CN V_3
    - Auriculotemporal nerve—to skin of external ear, posterior temple, anterior to ear
    - Buccal nerve—to skin of cheek
    - Mental nerve—to skin of chin and lower lip
- Facial nerve
  - Sole motor supply to muscles of facial expression
  - Has five main branches
    - Temporal
    - Zygomatic
    - Buccal
    - Mandibular
    - Cervical
  - Names refer to areas they supply

Other Muscles Associated with the Face: Muscles of Mastication

The muscles of mastication include four pairs of muscles (left and right side) that attach to the mandible, are embryological derivatives of the first pharyngeal arch, are all innervated by the mandibular division of the trigeminal nerve (CN V_3), and are important in biting and chewing food.

- All attach to mandible.
- Responsible for biting and chewing (movements at temporomandibular joint [TMJ])
- All are innervated by branches of mandibular nerve (CN V_3).
- All are supplied by branches of maxillary artery.
- Group of four muscles
  - Temporalis
    - Large, fan-shaped
    - Covers most of the side of the head
    - Inserts on coronoid process of mandible
  - Masseter
    - Deep to parotid gland and crossed by parotid duct
    - Inserts on entire lateral surface of ramus of mandible except for condylar process
  - Lateral pterygoid
    - Deep to temporal muscle
    - Runs horizontally backward from infratemporal fossa and lateral pterygoid plate to insert on mandible
    - Covered with dense pterygoid plexus of veins
  - Medial pterygoid
    - Covered by inferior fibers of lateral pterygoid
    - Runs from inner surface of lateral pterygoid plate inferiorly to inner surface of ramus of mandible

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Temporalis	Floor of temporal fossa and deep temporal fascia	Coronoid process and ramus of mandible	Mandibular nerve (V_3)—deep temporal nerves	Elevates mandible; posterior fibers retrude mandible	Superficial temporal and maxillary arteries, middle, anterior, and posterior deep temporal arteries
Masseter	Zygomatic arch	Ramus of mandible and coronoid process	Mandibular nerve (V_3)—via masseteric nerve	Elevates and protrudes mandible; deep fibers retrude it	Transverses facial artery; masseteric branch of maxillary and facial arteries
Medial pterygoid	*Superior head*: infratemporal surface of greater wing of sphenoid *Inferior head*: lateral pterygoid plate	Medial surface of ramus and angle of mandible inferior to mandibular foramen	Mandibular nerve (V_3)—nerve to medial pterygoid	Bilateral: protrude and elevate mandible Unilaterally and alternate: produces side-to-side movements	Facial and maxillary arteries
Lateral pterygoid	*Superior head*: infratemporal surface of greater wing of sphenoid *Inferior head:* lateral pterygoid plate	Pterygoid fovea, capsule of temporomandibular joint, articular disc	Mandibular nerve (V_3)—muscular branches from anterior division	Bilateral: protrude mandible Unilaterally and alternate: produces side-to-side grinding	Muscular branches of maxillary artery

CLINICAL POINTS

SCALP LACERATIONS

- Scalp has rich blood supply.
- Bleeding from scalp lacerations often profuse, because blood enters periphery of scalp and vessels anastomose.
- Because of dense connective tissue in second layer of scalp, bleeding vessels do not retract into wound but stay open.
- Patient can exsanguinate if bleeding is not controlled.
- Bleeding controlled initially by direct pressure initially followed by suturing in layers rather than tying individual vessels.

BLOOD OR INFECTIONS IN THE SCALP

- Blood or pus from an infection collects in loose connective tissue.
- Can spread easily
- Prevented from passing into neck or subtemporal regions because of attachments of epicranial aponeurosis

- Fluid can descend into orbits because orbitalis muscle attaches to skin in this region.
- Orbital hematomas commonly occur following injury to the scalp.

FACIAL PALSY (BELL'S PALSY)

- Facial nerve palsy without a known cause
- Can follow exposure to cold, dental work, Lyme disease, or otitis media
- Results in inflammation, compression, or edema of the nerve
- Facial nerve supplies muscles of facial expression.
- Thus result is loss of facial muscle tone on affected side.
- Symptoms generally seen
  - Paralysis of orbicularis oris causes drooping of mouth on affected side and dribbling of saliva
  - Paralysis of orbicularis oculi causes eyelid to droop and evert, leaving cornea inadequately lubricated and eye constantly tearing
  - Paralysis of buccinator together with orbicularis oris leads to accumulation of food between cheek and teeth when chewing

Sites of Lesions of the Facial Nerve and Resulting Symptoms

Site of Lesion	Symptoms
Below stylomastoid foramen (parotid gland tumor, trauma	(1) Facial paralysis: mouth draws to opposite side; on affected side, patient unable to close eye or wrinkle forehead; food collects between teeth and cheek as a result of paralysis of buccinator muscle.
Facial canal	(2) All symptoms of (1), plus loss of taste in anterior tongue and decreased salivation on affected side as a result of chorda tympani involvement. Hyperacusis as a result of effect on nerve branch to stapedius muscle.
Geniculate ganglion	(3) All symptoms of (1) and (2), plus pain behind ear. Herpes of tympanum and of external auditory meatus may occur.
Intracranial and/or internal auditory meatus	(4) All symptoms of (1–3), plus deafness as a result of involvement of eighth cranial nerve.

MEMORY AIDS

Layers of scalp: **SCALP**
Skin
Connective Tissue
Aponeurosis
Loose connective tissue
Periosteum of skull

Branches of facial nerve: "**T**o **Z**anzibar **B**y **M**otor **C**ar"
Temporal
Zygomatic
Buccal
Mandibular
Cervical

Four muscles of mastication: **MTPP** (which can be read as "Empty Peepee")
Masseter
Temporal
lateral **P**terygoids
medial **P**terygoids

1.4 NECK

Study Aims

At the end of your study, you should be able to:

- Outline the gross structure of the neck
- Describe the anterior and posterior triangles of the neck: boundaries and contents
- Know the smaller triangles of the neck within the posterior and anterior triangles: boundaries and content
- Know the fascial layers of the neck
- Know the contents of the compartments the fascial layers create

GUIDE

NECK—GENERAL DESCRIPTION

- Junction between head and thorax
- Extends from base of skull superiorly to thoracic inlet inferiorly
- Supports head
- Skeleton
  - Bones to which muscles of neck attach
  - Seven cervical vertebrae
  - Hyoid bone
  - Manubrium of the sternum
  - Clavicle
- Contains
  - Blood vessels, nerves, and lymphatics traversing to and from head and supplying muscles and viscera of neck
  - Segments of digestive system: pharynx and esophagus
  - Segments of respiratory system: larynx and trachea
  - Endocrine glands: thyroid and parathyroid glands

Triangles of the Neck

- Sternocleidomastoid (SCM) on each side of neck divides each side into two triangles.
  - Anterior
  - Posterior
- Facilitates description of anatomy of the neck
- Posterior triangle
  - Boundaries
    - Posterior—anterior border of trapezius
    - Anterior—posterior border of SCM
    - Inferior—medial third clavicle
    - Roof—investing layer of deep cervical fascia
    - Floor—muscles

- Muscles of floor
  - Splenius capitis
  - Levator scapulae
  - Middle scalene
  - Posterior scalene
- Vessels in triangle
  - External jugular vein
  - Subclavian vein
  - Third part of subclavian artery
  - Transverse cervical artery (from thyrocervical trunk)
  - Suprascapular artery (from thyrocervical trunk)
  - Occipital artery (from external carotid)
- Nerves in triangle
  - Accessory nerve (cranial nerve [CN] XI)
  - Ventral rami (roots) of brachial plexus
  - Cutaneous branches of cervical plexus
  - Suprascapular nerve
  - Phrenic nerve
- Subdivided by inferior belly of omohyoid
  - Occipital triangle
    - Larger triangle superiorly
    - Crossed by accessory nerve
  - Supraclavicular triangle
    - Smaller inferior triangle
    - Contains external jugular vein, suprascapular artery, and subclavian artery

- Anterior triangle
  - Boundaries
    - Lateral—anterior border of SCM
    - Anterior—anterior midline of neck
    - Superior—inferior mandible
  - Divided into four smaller triangles for descriptive purposes
  - Submandibular triangle (1)
    - Between inferior mandible and anterior and posterior bellies of digastric muscle
    - Contains submandibular gland
    - Submandibular duct
    - Submandibular lymph nodes
  - Submental triangle (2)
    - Between body of hyoid bone and right and left anterior bellies of digastric muscles
    - Apex is mandibular symphysis
    - Contains submental lymph nodes
  - Carotid triangle (3)
    - Bounded by anterior belly of omohyoid, posterior belly of digastric, and anterior border of SCM
    - Contains carotid sheath, with common carotid artery, internal jugular vein, and vagus nerve
    - Bifurcation of common carotid to internal and external carotid arteries
    - Carotid sinus
    - Carotid body
  - Muscular triangle (4)
    - Bounded by anterior border of SCM, superior belly of omohyoid, midline of neck
    - Contains infrahyoid muscles, thyroid, parathyroid
    - Contains
      - Cutaneous nerves and vessels
      - Lymphatics
      - Fat
      - Platysma muscle anteriorly

Fascial Layers of Neck

- Superficial fascia
  - Between dermis and investing layer of deep fascia
- Deep fascia
  - Consists of three layers
    - Investing
    - Pretracheal
    - Prevertebral
  - Also includes carotid sheath: condensation of deep fascia around carotid vessels
- Investing layer of deep fascia
  - Surrounds entire neck, beneath superficial fascia
  - Inferior attachments
    - Manubrium
    - Superior border clavicle
    - Acromion
    - Spine scapula
  - Superior attachments
    - Superior nuchal line
    - Zygomatic arches
    - Angle mandible
    - Mastoid process
    - Spinous processes of cervical vertebrae
  - Splits to enclose sternocleidomastoid and trapezius muscles
  - Encloses parotid and submandibular glands
  - Forms roof of anterior and posterior triangles neck
- Pretracheal fascia
  - Only in anterior neck, from hyoid bone to fibrous pericardium
  - Invests infrahyoid muscles
  - Visceral layer invests
    - Trachea
    - Thyroid and parathyroid glands
    - Esophagus
  - Attaches inferiorly to adventitia of great vessels
  - Attaches superiorly
    - Thyroid cartilage
    - Buccopharyngeal fascia of pharynx
  - Blends laterally with carotid sheath
- Prevertebral fascia
  - Sheath for C1–T3 vertebrae and associated muscles
    - Longus colli and capitis
    - Anterior, middle, and posterior scalenes
    - Deep cervical muscles
  - Described as having two laminae: anterior and posterior
  - Superior attachment of both laminae to base of skull
  - Inferior attachment
    - Anterior lamina to anterior longitudinal ligament and posterior esophagus anteriorly
    - Posterior lamina to fascia over thoracic vertebral column posteriorly
  - Extends laterally as axillary sheath around axillary artery and brachial plexus

Carotid Sheath

- Condensation of fascia around great vessels of the neck
- Extends from base of skull to root of neck
- United medially with prevertebral fascia

- Contains
  - Common carotid artery
  - Internal carotid artery
  - Internal jugular vein
  - Vagus nerve (CN X)
  - Deep cervical lymph nodes
  - Sympathetic fibers
- Communicates inferiorly with mediastinum

Facial Spaces

- Retropharyngeal space
  - Largest and most significant space in neck
  - Potential space between prevertebral layer of deep fascia and buccopharyngeal fascia
  - From base of skull to posterior mediastinum
  - Permits movement of pharynx, larynx, trachea, and esophagus during swallowing
  - Infection originating in pharyngeal area can spread to retropharyngeal space and inferiorly into superior mediastinum.
- Pretracheal space
  - Space between investing fascia and pretracheal fascia
  - Limited by attachments of fascia to thyroid cartilages superiorly
  - Can spread into thorax anterior to pericardium
- Space between laminae of prevertebral fascia
  - Critical space
  - Extends from base of skull and through thorax

ANATOMICAL POINTS

- **Spinal accessory nerve** has a subcutaneous course in posterior triangle and can be damaged during surgery. Injury causes weakness of sternocleidomastoid and trapezius muscles.
- The **phrenic nerve** arises from cervical nerve roots to supply the diaphragm. Irritation of the diaphragm, (e.g., because of infection), can cause referred pain to the C3, C4, C5 dermatome (shoulder).

CLINICAL POINTS

TORTICOLLIS

- In adults, spasm of the SCM can cause pain and turning and tilting of the head (torticollis).
- Congenital torticollis can occur in infants due to a fibrous tissue tumor in the SCM that develops in utero.
- Head bends to affected side and face turns away.
- Facial asymmetry can occur because of growth retardation on affected side.

THORACIC OUTLET SYNDROME

- Thoracic outlet syndrome is caused by compression of the subclavian artery, vein, and roots of the brachial as they emerge from the root of the neck.
- Patient may complain of pain, paresthesia in the arm as a result of nerve compression; pallor, coldness, and pain in the arm as a result of arterial compression; or swelling in the arm as a result of decreased venous and lymphatic drainage.
- Common cause is the presence of a C7 cervical rib.

MEMORY AIDS

Cervical spinal nerve roots that innervate diaphragm (C3, C4, C5):
C3, 4, 5 keeps the diaphragm alive

1.5 NASAL REGION

Study Aims

At the end of your study, you should be able to:

- Outline the structures that form the nasal region
- Describe the gross structure of the external nose
- Describe the nasal septum
- Define the boundaries of the nasal cavity
- Describe the structure of the nasal cavity including its blood supply, venous and lymphatic drainage, and innervation
- Describe the origin of the paranasal sinuses and their relationship to the nasal cavity

GUIDE

NASAL REGION

- External nose
- Nasal cavities
  - Divided by nasal septum
  - Filter, humidify, and warm air
  - Contain specialized olfactory mucosa
  - Receive secretions from paranasal sinuses and nasolacrimal duct
- Includes related paranasal sinuses

External Nose

The nose is composed primarily of cartilages except at the "bridge" of the nose where the nasal bone resides. Anteriorly, the air enters or leaves the nose via the nares, which open into the nasal vestibule, whereas posteriorly the nasal cavity communicates with the nasopharynx via paired apertures called the choanae.

- Composed of bone and hyaline cartilage
- Bones
  - Paired nasal bones
  - Frontal processes of maxilla
  - Nasal part frontal bone
- Cartilages
  - Paired lateral cartilages
  - Paired alar cartilages
  - Septal cartilage
- Associated muscles dilate and flatten nares (nostrils)
  - Nasalis
  - Compressor nares
  - Dilator nares
- Innervation via ophthalmic and maxillary divisions of trigeminal nerve (cranial nerve [CN] V_1 and V_2)
- Blood supply
  - Ophthalmic artery
  - Facial artery

- Venous drainage
  - Facial veins → internal jugular veins
  - Ophthalmic veins → cavernous sinus

Nasal Septum

The nasal cavity is separated from the cranial cavity by portions of the frontal, ethmoidal, and sphenoidal bones and from the oral cavity inferiorly by the hard palate. A nasal septum, usually deviated slightly to one side or the other, divides the nasal cavity into right and left chambers. The anterior third of the nasal septum is cartilaginous and the posterior two thirds is bony.

- Divides nasal cavity into two chambers
- Composed of
  - Bone
    - Vomer
    - Perpendicular plate of ethmoid
  - Septal cartilage
    - Septal cartilage articulated with edges of bony septum

Nasal Cavity

The lateral wall of the nasal cavity is characterized by three shell-like conchae, or turbinates, that protrude into the cavity, and along with their covering of nasal respiratory epithelium, they greatly increase the surface area for warming, humidifying, and filtering the air. At the most superior aspect of the nasal cavity resides the olfactory region, with its olfactory epithelium and specialized sensory cells for the detection of smells.

- Each cavity narrow above and wider below, separated from each other by nasal septum
- Extend from nares to choanae
  - Naris = external opening of nose
  - Choana = opening into pharynx
- Vestibule
  - First part of cavity
  - Lined with skin with hairs
  - Bounded laterally by alar cartilages
  - Limen nasi
    - Crescentic line
    - Marks upper limit of vestibule
- Nasal mucosa
  - Lines nasal cavities except for vestibule
  - Bound to periosteum and perichondrium of surrounding bones and cartilages
  - Extends into all chambers, cavities and sinuses communicating with nasal cavities
  - Upper one third is olfactory areas (mucosa).
  - Lower two thirds is respiratory areas (mucosa).
- Boundaries (walls) of nasal cavity
- Nasal conchae
  - Three horizontal projections from lateral wall
  - Superior, middle, and inferior nasal conchae
  - Divide nasal cavity into four areas
    - Superior meatus
    - Middle meatus
    - Inferior meatus
    - Spheno-ethmoidal recess
- Superior meatus
  - Between superior and middle conchae
  - Has openings from posterior ethmoidal sinuses
- Middle meatus
  - Wider and longer than superior
  - Depressed area—atrium—at anterior end
  - Ethmoidal infundibulum at anterior end
    - Leads to frontonasal duct
    - Duct leads to frontal sinus
  - Ethmoidal bulla (swelling)
    - Rounded projection at inferior root of middle meatus
    - Represents bulge of ethmoidal air cells (sinuses)
    - Groove called semilunar hiatus immediately beneath leads to infundibulum
  - Contains openings for frontal, maxillary, and anterior ethmoidal sinuses
    - Frontal sinus opening at anterior end of semilunar hiatus/infundibulum
    - Maxillary sinus opening at posterior end of semilunar hiatus
    - Variable openings for ethmoidal air cells
- Inferior meatus
  - Below inferior concha
  - Receives nasolacrimal duct opens into anterior end
- Spheno-ethmoidal recess
  - Posterior and superior to superior concha
  - Receives opening of sphenoidal sinus
- Innervation
  - Posterior region of nasal cavity
    - Nasal septum: maxillary nerve (CN V_2) → nasopalatine nerve to nasal septum
    - Lateral wall: lateral branches of lateral palatine nerve
  - Anterior and superior regions of nasal cavity: anterior and posterior ethmoidal nerves, branches of nasociliary nerve from ophthalmic nerve (CN V_1)
  - Olfactory epithelium innervated by olfactory nerve (CN I)
- Arterial supply
  - Sphenopalatine artery (branch of maxillary artery)
  - Anterior and posterior ethmoidal arteries
  - Greater palatine artery
  - Superior labial and lateral nasal branches of facial artery
- Venous drainage
  - Plexus of veins beneath nasal mucosa drains to
    - Sphenopalatine veins
    - Facial veins
    - Ophthalmic veins
- Lymphatic drainage
  - Posterior nasal cavity to retropharyngeal nodes
  - Anterior nasal cavity to submandibular nodes

Paranasal Sinuses

There are four pairs of paranasal sinuses, which are open chambers within several of the bones surrounding the nose and orbits. They are lined with respiratory epithelium, assist in warming and humidifying the inspired air, and drain their mucus secretions into the nasal cavities. Blowing the nose clears the nasal cavity and sinuses of excess secretions.

Sinus	Description
Frontal	Paired sinuses, lying anteriorly in frontal bone and draining into semilunar hiatus of middle meatus
Ethmoidal	Paired anterior, middle, and posterior sinuses in ethmoidal bone; anterior and middle draining into middle meatus (hiatus semilunaris and ethmoidal bulla, respectively), and posterior, into superior nasal meatus
Sphenoidal	Paired sinuses, in sphenoidal bone, draining into spheno-ethmoidal recess
Maxillary	Paired sinuses, in maxilla, draining into middle meatus (semilunar hiatus); largest sinus (20–30 mL)

- Extensions of nasal cavity into maxillary, ethmoidal, frontal, and sphenoidal bones
- Lined with respiratory epithelium
- Present at birth and increase in size until adulthood
- Air filled
- Frontal sinuses (2)
  - Between inner and outer tables of frontal bone
  - Can be detected around age 7
- Maxillary sinuses (2)
  - Largest of paranasal sinuses
  - Occupy most of body of maxillae
- Ethmoidal sinuses
  - Several in number
  - Not well developed until after age 2
- Sphenoidal sinuses
  - Derive from extensions of ethmoidal sinuses into sphenoidal bone around 2 years of age
  - Numbers different on either side
  - Bony septum between two sides
  - Only a thin plate of bone separates them from critical structures in the anterior and middle cranial fossae: optic nerves, pituitary gland, internal carotid arteries, cavernous sinuses.

CLINICAL POINTS

NASAL OBSTRUCTION

- Can occur either acutely or be longer in duration—chronic
- Causes include large adenoids (in children), tumors, deviated septum, and foreign bodies.
- Patient may complain of snoring, abnormal speech, or breathing difficulties when eating.

EPISTAXIS

- Nosebleed
- Common because of rich vascular supply to nose
- In younger people it occurs in the Little's area—where anterior ethmoidal artery, septal branches of sphenopalatine artery, superior labial arteries, and greater palatine artery converge
- In older people it can be related to hypertension.
- Treatment involves identifying source of bleeding and stopping bleeding by direct pressure, packing the nose, or cautery.

SINUSITIS

- Paranasal sinuses may become infected via continuity with nasal cavities.
- Inflammation and swelling of mucosa lining sinus
- Can be acute or chronic
- Bacterial infection usually follows a viral infection.
- Patient may complain of pain, nasal discharge, blocked nose, postnasal drip, and fever.
- Acute sinusitis is usually self-limiting.
- Chronic may require antibiotics and if recurrent sinus surgery.

MEMORY AIDS

Nasal Cavity: **N**ever **C**all **M**e **N**eedle **N**ose
Nares (external)
Conchae
Meatuses
Nares (internal)
Nasopharynx

1.6 ORAL REGION

Study Aims

At the end of your study, you should be able to:

- Understand the regions and boundaries of the oral cavity
- Know the major anatomical features of the lips, cheeks, and gingivae
- Describe the external features of the tongue
- Outline the intrinsic and extrinsic muscles of the tongue and their movements
- Describe the hard and soft palate and their anatomical features
- Describe the anatomy of the oral cavity related to the soft palate
- Know the muscles of the soft palate and their movements and innervation
- Outline the vascular supply and innervation of the palate
- Describe the parotid, submandibular, and sublingual salivary glands, including their vascular supply and innervation

GUIDE

ORAL CAVITY

- Oral vestibule
  - Narrow space between teeth and gingival and lips and cheeks
  - Size controlled by orbicularis oris, buccinator, risorius, and muscles controlling lips
  - Contains frenula (singular: frenulum)—midline mucosal folds from upper and lower lips to gums

- Oral cavity proper
  - Boundaries
    - Anterior: lips
    - Posterior: oropharyngeal isthmus to oropharynx
    - Roof: hard palate anteriorly and soft palate posteriorly
    - Floor: mucosa beneath tongue
    - Space occupied by tongue
- Anatomical features of lips
  - Orbicularis oris muscle and fibers of levator labii superioris, depressor anguli oris, zygomaticus major, and risorius muscles
  - Superior and inferior labial arteries and veins
    - From infra-orbital and facial vessels superiorly
    - From facial and mental vessels inferiorly
  - Branches of infra-orbital nerves (cranial nerve [CN] V_2) superiorly
  - Branches of mental nerves (CN V_3) inferiorly
  - Vermilion border: transition zone (border) of lip
  - Nasolabial grooves from nose to just lateral of angle of mouth separated lips from cheek
  - Philtrum: depression from nasal septum to vermilion border of upper lip
  - Labiomental groove separates lower lip from chin.
  - Labial frenula: midline mucosal folds with a free edge that extend from upper and lower lips to gums
  - Anatomical features of cheeks
    - Lateral walls of oral cavity
    - Form zygomatic prominences over zygomatic bones
    - Principal muscle is buccinator
    - Buccal fat pad external to buccinator
    - Supplied by buccal branches of maxillary artery
    - Innervated by buccal branches of mandibular nerve (CN V_3)
  - Gingivae
    - Composed of fibrous tissue covered by mucous membrane
    - Firmly attached to alveolar processes of mandible and maxilla and necks of teeth

TONGUE

- Highly mobile organ composed largely of muscle
- Main functions
  - Pressing food into pharynx during swallowing
  - Assisting in formation of words during speech
- External features of tongue anterior to sulcus terminalis
  - Root
    - Posterior one third
    - Attached to hyoid bone and mandible
  - Body: anterior two thirds
  - Apex or tip: pointed or rounded anterior end
  - Dorsum of tongue
    - V-shaped groove: sulcus terminalis
      - Divides tongue into oral and pharyngeal parts
      - Apex points to foramen cecum.
    - Foramen cecum
      - Small pit
      - Remnant of embryonic thyroglossal duct
- Numerous papillae of different types
  - Lingual papillae
    - Vallate
      - Anterior to sulcus terminalis
      - Large and flat-topped
      - Have taste buds
    - Foliate
      - Small folds on lateral side of tongue
      - Have taste buds
    - Filiform
      - Numerous and mainly arranged in rows parallel to sulcus terminalis
      - Sensitive to touch
    - Fungiform
      - Mushroom-shaped
      - Found on tip and sides of tongue
      - Have taste buds
- External features of tongue posterior to sulcus terminalis
  - Posterior to palatoglossal arches
  - Roughened surface due to underlying lymphatic follicles = lingual tonsil
- External features of inferior tongue
  - Lingual frenulum
    - Midline fold of mucosa from gingivae to posteroinferior surface of tongue
    - Connects tongue to floor of mouth
  - Sublingual caruncle
    - Papilla on either side of frenulum
    - Opening of duct of submandibular gland
- Muscles
  - Both intrinsic and extrinsic muscles are paired
  - All muscles act coordinately
  - Fibrous septum separates muscles of each half of tongue
  - Extrinsic muscles
    - Alter position of tongue
    - Genioglossus
      - Most of bulk of tongue
      - Contributes to protrusion of tongue
      - Moves tongue from side to side
    - Hyoglossus
      - Depresses tongue
      - Aids in retraction
    - Styloglossus
      - Mingles with fibers of hyoglossus
      - Creates central trough or furrow with genioglossus during swallowing
      - Retracts tongue and curls side
    - Palatoglossus
      - Largely a soft palate muscle
      - Elevates posterior tongue

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Genioglossus	Mental spine of mandible	Dorsum of tongue and hyoid bone	Hypoglossal nerve (CN XII)	Depresses and protrudes tongue	Sublingual and submental arteries
Hyoglossus	Body and greater horn of hyoid bone	Lateral and inferior aspect of tongue	Hypoglossal nerve (CN XII)	Depresses and retracts tongue	Sublingual and submental arteries
Styloglossus	Styloid process and stylohyoid ligament	Lateral and inferior aspect of tongue	Hypoglossal nerve (CN XII)	Retracts tongue and draws it up for swallowing	Sublingual artery
Palatoglossus	Palatine aponeurosis of soft palate	Lateral aspect of tongue	Vagus nerve via pharyngeal plexus	Elevates posterior tongue, depresses palate	Ascending pharyngeal arteries, palatine branches of facial and maxillary arteries

  - Intrinsic muscles
    - Alter shape of tongue
    - Superior longitudinal: curls tip of tongue superiorly
    - Inferior longitudinal
      - Curls tip of tongue inferiorly
      - Acts with superior longitudinal muscle to shorten and thicken tongue
    - Transverse: narrows tongue and increases height
    - Vertical: flattens and broadens tongue
- Vasculature
- Arterial supply
  - Principally from lingual artery, branch of external carotid
    - Dorsal lingual artery
    - Deep lingual artery
    - Sublingual artery
  - Minor contributions from tonsillar and ascending pharyngeal arteries
- Venous drainage
  - Accompanies arterial supply
  - Dorsal lingual veins
  - Deep lingual veins (join sublingual veins)
  - All drain, either directly or indirectly, to internal jugular vein.
- Lymphatic drainage
  - Tip (apex) to submental nodes
  - Anterior medial two thirds to inferior deep cervical nodes
  - Anterior lateral two thirds to submandibular nodes
  - Posterior one third to superior deep cervical nodes
- Innervation
  - All muscles of tongue except palatoglossus are supplied by hypoglossal nerve (CN XII).
  - Palatoglossus is supplied by pharyngeal plexus (CN IX via CN X).
  - Sensory to anterior two thirds of tongue
    - General sensory: lingual nerve (CN V_3)
    - Special sensory (taste): chorda tympani (CN VII)
  - General and special sensory to posterior one third of tongue: glossopharyngeal nerve (CN IX)

PALATE

- Forms roof of mouth and floor of nasal cavities
- Consists of two parts
  - Hard palate anteriorly
    - Formed from by palatine processes of maxillae and horizontal plates of palatine bones
    - Covered with periosteum and oral mucosa (inferiorly) and respiratory mucosa superiorly
    - Has five foramina
      - Incisive fossa behind central incisors transmits nasopalatine nerves via incisive canals
      - Paired greater palatine foramina medial to third molar transmits greater palatine vessels and nerves
      - Paired lesser palatine foramina posterior to greater palatine foramina transmits lesser palatine nerves and vessels
    - Mucus-secreting palatine glands beneath mucosa
    - Incisive papilla directly posterior to maxillary incisors
    - Palatine raphe
      - Midline ridge/groove
      - Represents line of fusion of embryonic palatal plates
  - Soft palate posteriorly
    - Moveable posterior third suspended from hard palate
    - No bony skeleton
    - Attaches to hard palate via aponeurotic palate
      - Expanded tendineus aponeurosis of tensor veli palatini muscles
      - Thick anteriorly
    - Muscular palate (tensor veli palatini) posteriorly
    - Posterior curved free margin has conical projection: uvula
- Anatomical features related to soft palate
  - Arches
    - Join soft palate to tongue and pharynx
    - Palatoglossal arch
      - Mucosal fold
      - Contains palatoglossus muscle

- Palatopharyngeal arch
  - Mucosal fold
  - Posterior to palatoglossal arch
  - Contains palatoglossus muscle
- Form anterior and posterior boundaries of tonsillar fossa on either side
- Tonsillar fossae
  - Contain palatine tonsils
  - Masses of lymphoid tissue between arches
- Fauces
  - Term for passage from oral cavity to oropharynx
  - Bounded by
    - Soft palate superiorly
    - Root of tongue inferiorly
    - Palatoglossal and palatopharyngeal arches laterally
- Muscles of soft palate
  - Four paired muscles descend from base of brain to palate
    - Levator veli palatine elevates soft palate during swallowing, opens auditory tube./
    - Tensor veli palatini tenses soft palate during swallowing.
    - Palatoglossus elevates posterior tongue.
    - Palatopharyngeus tenses soft palate and pulls pharynx superiorly and anteriorly during swallowing.
  - Unpaired musculus uvulae shortens uvula.

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Levator veli palatini	Temporal bone (petrous portion)	Palatine aponeurosis	Vagus nerve via pharyngeal plexus	Elevates soft palate during swallowing	Ascending palatine artery branch of facial artery and descending palatine artery branch of maxillary artery
Tensor veli palatini	Scaphoid fossa of medial pterygoid plate, spine of sphenoid, and auditory tube	Palatine aponeurosis	Mandibular nerve	Tenses soft palate and opens auditory tube during swallowing and yawning	Ascending palatine artery branch of facial artery and descending palatine artery branch of maxillary artery
Palatopharyngeus	Hard palate and superior palatine aponeurosis	Lateral pharyngeal wall	Vagus nerve via pharyngeal plexus	Tenses soft palate; pulls walls of pharynx superiorly, anteriorly, and medially during swallowing	Ascending palatine artery branch of facial artery and descending palatine artery branch of maxillary artery
Musculus uvulae	Nasal spine and palatine aponeurosis	Mucosa of uvula	Vagus nerve via pharyngeal plexus	Shortens, elevates, and retracts uvula	Ascending palatine artery branch of facial artery and descending palatine artery branch of maxillary artery

- Swallowing and the palate
  - Complex mechanism
  - Soft palate tenses to allow tongue to press against it.
  - Tongue squeezes bolus of food to back of oral cavity.
  - Soft palate elevates superiorly and posteriorly to prevent back flush of food into nasal cavity.
- Arterial supply
  - Branches of descending palatine artery on each side
    - Greater palatine artery
    - Lesser palatine artery
  - Ascending palatine artery from facial artery
- Venous drainage via pterygoid venous plexus
- Lymphatic drainage: deep cervical nodes
- Innervation
  - Sensory from pterygopalatine ganglion (from CN V_2)
    - Greater palatine nerve to hard palate
    - Nasopalatine nerve to anterior hard palate
    - Lesser palatine nerve to soft palate
  - Motor
    - Tensor veli palatini innervated by medial pterygoid nerve from otic ganglion (CN V_3)
    - All other muscles by cranial root of spinal accessory nerve (CN XI) via pharyngeal plexus

SALIVARY GLANDS

- Functions
  - Moisten and lubricate food
  - Begin digestion of starches
  - Contribute to
    - Ability to taste
    - Prevention of tooth decay
- Parotid gland
  - Largest salivary gland
  - Thin watery secretion
  - Found within investing cervical fascia
  - Occupies space between ramus of mandible and anterior border of sternocleidomastoid (SCM) muscle
    - Overlaps posterior masseter muscle
    - Deep part extends posteriorly to mastoid process and external auditory meatus.
  - Parotid duct
    - Emerges at anterior border of gland

    - Runs over masseter
    - Pierces buccinator to enter mouth opposite upper second molar
  - Structures passing through gland
    - Facial nerve
      - Enters gland and branches into two stems
      - Two stems give rise to five branches that emerge from borders of gland.
    - Superficial temporal vein
      - Runs through deeper part of gland
      - Unites with maxillary vein within gland to form retromandibular vein
    - External carotid artery through deep part of gland
  - Arterial supply
    - External carotid artery
    - Superficial temporal arteries
  - Venous drainage: retromandibular vein
  - Innervation
    - Great auricular nerve (C2 and C3 spinal nerves)
    - Auriculotemporal nerve (CN V_3)
    - Parasympathetic fibers from glossopharyngeal nerve (CN IX) via auriculotemporal from otic ganglion
    - Sympathetic fibers from external carotid plexus from cervical ganglia
- Submandibular gland
  - Lies superior and inferior to posterior half of mandible
  - Divided into superficial and deep parts by mylohyoid muscle
  - Duct
    - Opens at sublingual papilla, one on either side of lingual frenulum
    - Lingual nerve loops under duct.
  - Arterial supply: submental artery
  - Innervation
    - Secretomotor parasympathetic fibers
      - Presynaptic fibers from facial nerve via chorda tympani to submandibular ganglion
      - Postsynaptic fibers from cells in submandibular ganglion
    - Vasoconstrictive sympathetic fibers from superior cervical ganglion
- Sublingual glands
  - Smallest and deepest of glands
  - Lie in floor of mouth within sublingual folds, between mandible and genioglossus muscle
  - Numerous ducts open along sublingual folds
  - Arterial supply
    - Sublingual artery from lingual artery
    - Submental artery from facial artery
  - Innervation same as that for submandibular gland

CLINICAL POINTS

PAROTID TUMORS

- Most common salivary gland tumor, but still rare
- More common in people older than 40 years of age
- Patient usually presents with a slow-growing lump.
- If painful or affecting facial nerve, malignancy is suspected.
- Treatment is by surgical excision conserving facial nerve and its branches.

SIALOADENITIS

- Inflammation of salivary gland
- Can be caused by infection or obstruction of the duct of a gland
- Most commonly a result of bacterial infection (*Staphylococcus aureus*)
- Patient may present with pain, swelling, and fever.
- Submandibular gland is most commonly affected.
- Treatment is with antibiotics and/or increasing secretions with drugs.
- Relief of the obstruction may require surgery.

SIALOLITHIASIS

- Obstruction of the duct of a salivary gland with a calculus (stone)
- Commonly occurs in submandibular gland
- Patient presents with pain when eating and swelling.
- Ninety percent of stones are radio-opaque—diagnosis can be made on radiograph.
- Ultrasound or computed tomography (CT) can also be useful.
- Treatment is by removing the stone, increasing secretions with drugs, or surgical removal.

MEMORY AIDS

Three Tonsils: **People** *(or for short,* ***PPL****)* have three tonsils:
Pharyngeal
Palatine
Lingual

1.7 PHARYNX

Study Aims

At the end of your study, you should be able to:

- Know the general anatomy of the pharynx
- Describe the anatomy of the nasopharynx
- Describe the anatomy of the oropharynx
- Describe the anatomy of the laryngopharynx
- Know the muscles of the pharynx
- Know the vascular supply and lymphatic drainage of the pharynx
- Understand the innervation of the pharynx
- Outline the process of swallowing

GUIDE

PHARYNX: GENERAL ANATOMY

The pharynx is a muscular tube that is deficient anteriorly as a result of the openings of nasal and oral cavities and larynx—as revealed when the posterior wall is removed.

- Muscular tube
- Posterior to nasal and oral cavities
- Continuous with both esophagus and larynx
- Anterior to superior six cervical vertebrae and prevertebral muscles and fascia

- Retropharyngeal space = potential space between pharynx and prevertebral fascia
- Divided into three parts: nasopharynx, oropharynx, and laryngopharynx
- Nasopharynx
  - Posterior to nose and above soft palate
  - Lined with ciliated epithelia
  - Boundaries
    - Anterior: continuous with nasal cavities via choanae
    - Roof and posterior wall: body of sphenoid and base of occipital bone
    - Lateral: superior constrictor muscle
  - Contains openings of auditory (eustachian) tubes (from middle ear)
  - Salpingopharyngeal fold
    - Extends inferiorly from medial end of auditory tube
    - Covers salpingopharyngeus muscle—opens tube during swallowing
  - Ridge over opening = torus tubarius
  - Pharyngeal recess
    - Slitlike projection
    - Posterior to torus
  - Contains abundant lymphoid tissue
    - Incomplete ring in superior part of pharynx
    - Aggregates in certain areas = tonsils
    - Lymphoid tissue in mucus membrane of roof and posterior wall = adenoids
    - Lymphoid tissue near opening of auditory tube = tubal tonsil
- Oropharynx
  - From soft palate to superior ends of epiglottis
  - Boundaries
    - Anterior: oropharyngeal opening posterior one third tongue epiglottis
    - Lateral: palatoglossal and palatopharyngeal arches (containing palatoglossus and palatopharyngeus muscles)
    - Superior: soft palate
    - Posterior: superior and middle constrictor muscles
  - Contains palatine tonsils
    - Found in cleft between palatoglossal and palatopharyngeal arches
    - Tonsil lies on tonsillar bed = superior constrictor muscle and pharyngobasilar fascia.
  - Epiglottis
    - United to tongue by median and lateral glossoepiglottic folds
    - Depression between medial and lateral folds = epiglottic valleculae
- Laryngopharynx
  - From superior border of epiglottis to inferior border of cricoid cartilage
  - Lined with stratified squamous epithelium
  - Boundaries
    - Inferior: continuous with esophagus
    - Superior: continuous with oropharynx
    - Anterior: larynx
    - Posterior: middle and inferior constrictor muscles deep: Bodies of C4–C6 vertebrae
    - Lateral: middle and inferior constrictor muscles
  - Piriform recesses
    - Small depressions on either side of laryngeal inlet
    - Separated from inlet by ary-epiglottic folds
    - Bounded medially by thyroid cartilage and thyrohyoid membrane

Muscles of Pharynx

- Wall of pharynx is unique
  - Composed of outer circular and inner longitudinal layers of muscles
  - External circular layer consists of three constrictor muscles: pharyngeal constrictors
  - Inner longitudinal layer consists of three paired muscles.
- Pharyngeal constrictors = three muscles
  - Superior, middle, and inferior constrictor muscles form a muscular sleeve
  - Have strong internal facial lining: pharyngobasilar fascia
  - Contract involuntarily in sequence = peristalsis
  - All supplied by pharyngeal plexus of nerves
- Inner longitudinal layer = three muscles
  - Elevate larynx
  - Shorten pharynx
  - Act during swallowing and speaking
  - Stylopharyngeus
  - Palatopharyngeus
  - Salpingopharyngeus
- Gaps between constrictors
  - Areas where structures can enter and leave pharynx
  - Between superior constructor and skull
    - Levator veli palatini
    - Auditory tube
    - Ascending palatine artery
  - Between superior and middle constructor
    - Stylopharyngeus muscle
    - Glossopharyngeal nerve
    - Stylohyoid ligament
  - Between middle and inferior constrictor
    - Internal laryngeal nerve
    - Superior laryngeal artery and vein
  - Below inferior constructor
    - Recurrent laryngeal nerve
    - Inferior laryngeal artery

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Superior pharyngeal constrictor	Hamulus, pterygomandibular raphe, mylohyoid line of mandible	Median raphe of pharynx	Vagus nerve via pharyngeal plexus	Constricts wall of pharynx during swallowing	Ascending pharyngeal artery, ascending palatine and tonsillar branches of facial artery, dorsal branches of lingual artery
Middle pharyngeal constrictor	Stylohyoid ligament and horns of hyoid bone	Median raphe of pharynx	Vagus nerve via pharyngeal plexus	Constricts wall of pharynx during swallowing	Ascending pharyngeal artery, ascending palatine and tonsillar branches of facial artery, dorsal lingual branches of lingual artery
Inferior pharyngeal constrictor	Oblique line of thyroid cartilage and cricoid cartilage	Median raphe of pharynx	Vagus nerve via pharyngeal plexus	Constricts wall of pharynx during swallowing	Ascending pharyngeal artery, branches of superior thyroid artery
Salpingopharyngeus	Auditory (pharyngotympanic) tube	Side of pharyngeal wall	Vagus nerve via pharyngeal plexus	Elevates pharynx and larynx during swallowing and speaking	Pharyngeal branch of ascending pharyngeal artery
Stylopharyngeus	Medial aspect of styloid process	Pharyngeal wall	Glossopharyngeal nerve (CN IX)	Elevates pharynx and larynx during swallowing and speaking	Ascending pharyngeal artery, ascending palatine and tonsillar branches of facial artery, dorsal branches of lingual artery

Arterial Supply

- Tonsillar artery (from facial) to tonsil
- Branches from
  - Ascending pharyngeal
  - Lingual
  - Ascending and descending palatine

Venous Drainage

- External palatine vein → pharyngeal plexus
- Pharyngeal venous plexus → internal jugular vein

Lymphatic Drainage

- General drainage to deep cervical nodes
- From tonsillar tissue to nodes near angle of mandible and tonsillar (jugulodigastric) node

Innervation

- From pharyngeal plexus (motor and almost all sensory)
- Motor
  - From pharyngeal plexus via vagus nerve from cranial root of accessory nerve (cranial nerve [CN] XI)
    - To all muscles of pharynx except stylopharyngeus (CN V_2)
  - Branches from external and recurrent branches of vagus
    - To inferior constrictor
- Sensory
  - Mainly from glossopharyngeal nerve (CN IX) via plexus
  - Also
    - Maxillary nerve (CN V_2) to anterior and superior nasopharynx
    - Tonsillar nerves from branches of glossopharyngeal and vagus (CN X)

Swallowing (Deglutition)

- Voluntary
  - When food is in the mouth, breathing occurs through the nasopharynx.
  - Food is chewed (masticated) and mixed with saliva to produce a bolus.
  - Bolus of food is compressed against hard palate.
  - Palatoglossal folds relax.
  - Muscles of tongue and soft palate push bolus into oropharynx.
  - Cycle lasts 1 to 2 seconds.
- Involuntary
  - Reflexive, mediated via glossopharyngeal nerve
  - Nasopharynx is closed off by tension and elevation of soft palate.
    - Prevents reflux of food/fluids into the nose.
    - Mediated by tensor veli palatine and levator veli palatine muscles
  - Suprahyoid muscles and longitudinal pharyngeal muscles contract
    - Elevate larynx
    - Close epiglottis
    - Propel bolus
- Involuntary
  - Food propelled through pharynx by peristalsis (sequential contraction of all three constrictors)
- On reaching distal end of pharynx, high pressure causes relaxation of terminal part of inferior constrictor.
  - Called cricopharyngeus muscle
  - Serves as superior esophageal sphincter
  - Food enters the esophagus
- As bolus passes pressure drops, sphincter closes.
- Larynx and epiglottis return to normal positions.

ANATOMICAL POINTS

- The piriform fossa is a common site for fish bones to lodge. It is also a site where pharyngeal tumors can grow undetected for a period of time.
- Aggregations of lymphoid tissue in the nasopharynx are called adenoids. They can become enlarged in children, causing obstruction of the nasopharynx and forcing the child to breathe through the mouth.

CLINICAL POINTS

PHARYNGITIS

- Also called a sore throat
- Usually caused by viral infection
- In children, common cause of bacterial pharyngitis is beta-hemolytic streptococcus.
- If infection is severe, auditory tubes can become blocked, predisposing to otitis media.
- Patient may complain of pain on swallowing and pain referred to the ear.
- On examination, the throat may be reddened and cervical lymph nodes may be enlarged.

TONSILLECTOMY

- Surgical removal of the palatine and lingual tonsils
- Tonsillectomy is advised if the patient has experienced recurrent attacks of tonsillitis, particularly if they resulted in airway obstruction and hearing difficulties.
- A major and common surgical procedure performed in children in the United States
- Recovery is usually within 2 weeks, although for adults this may take longer and can have a higher complication rate.

1.8 LARYNX AND THYROID GLAND

Study Aims

At the end of your study, you should be able to:

- Know the general anatomy of the larynx
- Describe the cartilaginous skeleton of the larynx
- Describe the membranes of the larynx
- Know the internal anatomy of the larynx
- List the intrinsic and extrinsic muscles of the larynx and their function
- Describe the arterial supply, venous and lymphatic drainage, and innervation of the larynx
- Describe the structure of the thyroid gland
- Describe the structure of the parathyroid glands

GUIDE

LARYNX: GENERAL ANATOMY

- Organ of phonation and sphincter guarding lower respiratory tract
- Approximately 8 cm long
- Connects oropharynx with trachea
- Lies anterior to prevertebral muscles, fascia, and bodies of C3–C6 vertebrae

Laryngeal Skeleton

- Comprises three paired and three nonpaired cartilages
- Epiglottic cartilage (epiglottis)
  - Leaf-shaped elastic cartilage
  - Posterior to root of tongue and hyoid bone, anterior to laryngeal inlet
  - Broad superior end is free
  - Inferior end attached in midline to angle of thyroid laminae by thyro-epiglottic ligament
  - Quadrangular membranes run between lateral sides of epiglottic cartilage and arytenoid cartilages on either side.
  - Upper free margin of quadrangular membrane + covering mucosa = ary-epiglottic fold
  - During swallowing overlies laryngeal inlet
- Thyroid cartilage
  - Composed of two flat laminae
  - Lower two thirds of laminae fuse in midline to form laryngeal prominence (Adam's apple).
  - Upper one third of laminae diverge to form superior thyroid notch.
  - Posterior superior border of each plate projects superiorly as superior horns.
  - Posterior inferior border of each plate projects inferiorly as inferior horns.
  - Superior horns and superior borders of laminae attach to hyoid bone by thyrohyoid membrane.

- Cricoid cartilage
  - Signet ring–shaped, signet (lamina) facing posteriorly
  - Strong, thick, complete circle of cartilage
  - Attached to inferior thyroid by median cricothyroid ligament
  - Attached to first tracheal ring by cricotracheal ligament
- Arytenoid cartilages (paired)
  - Pyramid shaped with three sides
  - Articulate with lateral superior parts of cricoid lamina
  - Has three processes
    - Apex at superior end
    - Vocal process projects anteriorly.
    - Muscular process projects laterally.
  - Apex: corniculate cartilage sits atop; attaches to ary-epiglottic fold
  - Vocal process: posterior attachment for vocal ligament
  - Muscular process: attachment for posterior and lateral crico-arytenoid muscles
- Corniculate and cuneiform cartilages
  - Nodules in posterior ary-epiglottic folds
  - Cuneiforms do not attach to other cartilages.
  - Corniculates attach to apices of arytenoids.

Membranes of Laryngeal Skeleton.

- Cricothyroid ligaments
  - Median cricothyroid ligament
  - Lateral cricothyroid ligaments (conus elasticus)
  - Both attach to cricoid cartilage to inferior border of thyroid cartilage.
  - Medial free edge of lateral cricothyroid ligaments = vocal ligaments, basis of true vocal cords
- Quadrangular membrane
  - Inelastic connective tissue
  - Attaches lateral aspects of arytenoids and epiglottis
  - Lower free border = vestibular ligament (false vocal cord)
    - Covered by vestibular fold
    - Above vocal fold
    - Extends from thyroid cartilage to arytenoid cartilage
  - Upper free border forms ary-epiglottic ligament
    - Covered with mucosa
    - Called ary-epiglottic fold
- Thyrohyoid membrane
  - Bridges gap between superior border and superior horns of thyroid cartilage
  - Pierced by superior laryngeal vessels and internal laryngeal nerve
- Mucous membrane
  - Respiratory epithelium except over true and ary-epiglottic folds
  - Composed of stratified squamous epithelium

Internal Anatomy of the Larynx

- Laryngeal cavity
  - From laryngeal inlet to tracheal cavity
  - Can be divided into three parts
    - Vestibule—above vestibular folds
    - Ventricle—sinus between vestibular folds above and vocal folds below
    - Infraglottic cavity—from below vocal folds to inferior border of cricoid cartilage
- Vocal folds
  - Paired, project into laryngeal cavity on either side
  - Consist of
    - Vocal ligament—medial free edge of lateral cricothyroid ligament (conus elasticus)
    - Vocalis muscle—medial fibers of thyroid arytenoids muscle
    - Overlying mucosa
  - Source of sound
  - Produce audible vibrations when free edges of folds closely approximate each other
  - Are sphincter of larynx when folds are tightly approximated
- Rima glottidis
  - Space between vocal folds
  - Varies in size with activity
    - During normal breathing: narrow wedge
    - During forced respiration: wide apart
    - During phonation: slitlike
- Vestibular folds (false vocal cords)
  - Folds of mucous membrane over vestibular ligaments superior to vocal folds
  - Extend between thyroid and arytenoids cartilages
  - Protective in function
- Ventricle of larynx: lateral outpocketings between vocal and vestibular folds on either side

Muscles of the Larynx

- Extrinsic muscles
  - Attached to hyoid bone and thus move thyroid
  - Infrahyoid muscles: lower larynx and hyoid bone
    - Sternohyoid
    - Omohyoid
    - Sternothyroid
    - Thyrohyoid
  - Suprahyoid muscles: fix hyoid or elevate hyoid bone and larynx
    - Stylohyoid
    - Digastric
    - Mylohyoid
  - Stylopharyngeus—elevates hyoid bone and larynx
- Intrinsic muscles
  - Alter length and tension of vocal cords
  - Alter rima glottides
  - Adductors
    - Lateral crico-arytenoid muscles
    - Transverse arytenoids
  - Abductors: posterior crico-arytenoid muscles
  - Sphincters
    - Transverse arytenoid muscles
    - Oblique arytenoid muscles
    - Ary-epiglottic muscles
  - Tensors: cricothyroid muscles
  - Relaxers
    - Thyro-arytenoid muscles
    - Vocalis muscles
  - All except cricothyroid supplied by recurrent laryngeal nerve

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Cricothyroid	Anterior cricoid cartilage	Inferior border of thyroid cartilage and its inferior horn	External branch of superior laryngeal nerve	Lengthens and tenses vocal ligaments	Superior and inferior thyroid arteries
Posterior crico-arytenoid	Posterior surface of lamina of cricoid cartilage	Muscular process of arytenoid cartilage	Recurrent laryngeal nerve	Abducts vocal folds	Superior and inferior thyroid arteries
Lateral crico-arytenoid	Arch of cricoid cartilage	Muscular process of arytenoid cartilage	Recurrent laryngeal nerve	Adducts vocal folds	Superior and inferior thyroid arteries
Thyro-arytenoid	Posterior aspect of thyroid cartilage	Muscular process of arytenoid cartilage	Recurrent laryngeal nerve	Shortens and relaxes vocal cords, sphincter of vestibule	Superior and inferior thyroid arteries
Vocalis	Vocal process of arytenoid cartilage	Vocal ligament	Recurrent laryngeal nerve	Tenses anterior vocal ligament and relaxes posterior vocal ligament	Superior and inferior thyroid arteries
Transverse and oblique arytenoids	Arytenoid cartilage	Opposite arytenoid cartilage	Recurrent laryngeal nerve	Closes intercartilaginous portion of rima glottides	Superior and inferior thyroid arteries

Joints of the Larynx and Movements at the Joints

- Cricothyroid joints
  - Thyroid cartilage glides and rotates here.
  - Changes length of vocal folds
- Crico-arytenoid joints: movement of arytenoid cartilage on lamina of cricoid
  - Slide toward and away from each other
  - Rotate
  - Tilt forward and back

Arterial Supply to Larynx

- Superior laryngeal artery
  - Through gap in thyrohyoid membrane
  - Supplies internal larynx
  - Accompanied by superior laryngeal nerve
- Inferior laryngeal artery
  - Supplies inferior internal larynx
  - Accompanied by recurrent laryngeal nerve

Venous Drainage of Larynx

- Superior laryngeal vein to internal jugular vein
- Inferior laryngeal vein to inferior thyroid vein or thyroid venous plexus (left brachiocephalic)

Lymphatic Drainage of Larynx

- Above folds: to deep cervical nodes
- Below folds: to paratracheal nodes to deep cervical nodes

Innervation of Larynx

- Sensory
  - Above vocal folds: internal laryngeal nerve (branch of superior laryngeal)
  - Below vocal folds: inferior laryngeal nerve (branch of recurrent laryngeal nerve)
- Motor
  - Recurrent laryngeal nerve to all intrinsic muscles except cricothyroid
  - External laryngeal nerve to cricothyroid

THYROID GLAND

- H-shaped endocrine gland
- Produces two hormones
  - Thyroid hormone—controls metabolic rate
  - Calcitonin—controls calcium metabolism
- Overlies anterior and lateral surface of trachea
- Enclosed in thin fibrous capsule with septa into gland
- Surrounded by pretracheal fascia (therefore moves on swallowing)
- Two lateral lobes linked by isthmus
  - Lobes extend from second to fifth tracheal ring
  - Isthmus lies at third tracheal ring
- Occasionally a pyramidal lobe extends superiorly from isthmus on left side.
- Anatomical relationships
  - Anterior: sternohyoid and sternothyroid muscles, jugular vein
  - Anterolateral: infra-hyoid muscles, sternocleidomastoid
  - Posterolateral: carotid sheath
  - Posteromedial: trachea, larynx, esophagus

Innervation

- Parasympathetic: external branch of superior laryngeal nerve (branch vagus n.)
- Sympathetic
  - From superior, middle, and inferior cervical ganglia
  - Vasomotor, not secretomotor

Arterial Supply

- Superior thyroid artery
  - Branch of external carotid artery
  - Divides into anterior and posterior branches
  - Anterior branch
    - Supplies anterior thyroid
    - Anastomoses with opposite anterior branch
  - Posterior branch
    - Supplies posterior thyroid
    - Anastomoses with inferior thyroid artery

- Inferior thyroid artery
  - Branch thyrocervical trunk from subclavian artery
  - Supplies inferior pole of thyroid
- Thyroid IMA artery
  - Branch of aorta
  - Occurs in 10% of all people
  - Unpaired, on left of midline
  - Supplies isthmus

Venous Drainage

- Three pairs of thyroid veins
- Superior thyroid vein
  - Drains superior region of thyroid
  - Tributary of internal jugular
- Middle thyroid veins
  - Drain middle of gland
  - Tributaries of internal jugular
- Inferior thyroid veins
  - Drain inferior region of thyroid
  - Tributaries of brachiocephalic vein

Lymphatic Drainage

- Lymphatic vessels run with arteries.
- Drain to capsular network of lymphatics
- To prelaryngeal, pretracheal, or paratracheal nodes
- To deep cervical nodes

Innervation

Sympathetic from cervical sympathetic ganglia

Parathyroid Gland

- Small, oval endocrine glands
- On medial half of posterior surface of lateral lobes of thyroid, external to capsule
- Two pairs of glands
  - Superior glands slightly above entrance of inferior thyroid arteries
  - Inferior glands slightly below entrance of inferior thyroid arteries
- Arterial supply
  - Superior thyroid artery
  - Inferior thyroid artery
  - Thyroid ima artery
- Venous drainage
  - Parathyroid veins
  - To thyroid plexus of veins
- Lymph drainage: paratracheal and deep cervical lymph nodes

CLINICAL POINTS

SEVERANCE OF RECURRENT LARYNGEAL NERVE

- Recurrent laryngeal nerve (supplies intrinsic muscles larynx)
- Closely associated with inferior thyroid artery and needs to be avoided during neck surgery
- If unilateral damage, voice hoarseness may result because one vocal fold cannot approximate the other.
- If bilateral damage, loss of voice results because vocal folds cannot approximate each other (be adducted).

THYROID LUMPS

- Lumps in thyroid can be single, multiple.
- Solitary nodules are likely to be benign (80%).
- Investigation includes history, examination, and fine-needle aspiration of the gland for cytology and radionucleotide imaging.
- Most common malignancy is papillary thyroid cancer.
- Treatment is total thyroidectomy.

HYPERTHYROIDISM

- Medical condition with increased activity of the thyroid gland
- Results in excessive amount of circulating thyroid hormones
- Leads to increased rate of metabolism
- Affects about 1% of women and 0.1% of men
- Thyrotoxicosis is a toxic condition caused by an excess of thyroid hormones from any cause.
- Hyperthyroidism with diffuse goiter (Graves' disease)
- Most common cause of hyperthyroidism in patients younger than 40 years
- Excess synthesis and release of thyroid hormone (T_3 and T_4) result in thyrotoxicosis.
- Thyrotoxicosis upregulates tissue metabolism and leads to symptoms indicating increased metabolism.

MNEMONICS

Four cartilages in the larynx: **TEAC**
Thyroid, **E**piglottis, **A**rytenoid, **C**ricoid

Note: TEAC is a manufacturer of audio products. Associate the TEAC sound with the vocal cords and you can make a connection.

1.9 ORBIT AND CONTENTS

Study Aims

At the end of your study, you should be able to:

- Define the boundaries, content, and function of the bony orbit
- Know the foramina of the bony orbit and what they transmit
- Describe the anatomy of the eyelids
- Describe the anatomy of the lacrimal apparatus and know its functions
- Know the anatomy of the eyeball and the composition of its three layers
- Understand the roles of the refractive structures and media of the eyeball
- Outline the key extra-ocular and intra-ocular muscles and their function
- Know the vascular supply of the eye
- Outline the innervation of the eye

GUIDE

BONY ORBIT

- Cavity containing and protecting five sixths of eyeball, associated muscles, nerves, and vessels
- Opening is protected by a thin moveable fold: the eyelid.
- Supports, protects, and maximizes the functions of the eye
- Pyramidal shape with apex directed posteriorly and base anteriorly
- Boundaries
  - Roof
    - Orbital plate of frontal bone
    - Lesser wing of sphenoid
    - Fossa for lacrimal gland found in orbital part
  - Floor
    - Orbital plate of maxilla
    - Some contributions from zygomatic and palatine bones
    - Contains inferior orbital fissure from apex to orbital margin
  - Medial wall
    - Paper thin
    - Orbital plate of ethmoidal bone
    - Some contributions from frontal, lacrimal, and sphenoidal bones
    - Indented by lacrimal fossa for lacrimal sac
  - Lateral wall
    - Frontal process of zygomatic bone
    - Greater wing of sphenoid
  - Apex
    - Lesser wing of sphenoid
    - Contains optic canal medial to superior orbital fissure
  - Foramina of orbital cavity

Foramen	Location	Structures Transmitted
Supra-orbital groove	Supra-orbital margin	Supra-orbital nerve and blood vessels
Infra-orbital groove and canal	Orbital plate of maxilla (floor)	Infra-orbital nerve and blood vessels
Nasolacrimal canal	Medial wall	Nasolacrimal duct
Inferior orbital fissure	Between greater wing of sphenoid and maxilla	Maxillary nerve Zygomatic branch maxillary nerve Ophthalmic vein Sympathetic nerves
Superior orbital fissure	Between greater and lesser wings of sphenoid	Lacrimal nerve Frontal nerve Trochlear nerve Oculomotor nerve Abducent nerve Nasociliary nerve Superior ophthalmic vein
Optic canal	Lesser wing of sphenoid	Optic nerve Ophthalmic artery
Zygomaticofacial foramen	Lateral wall	Zygomaticofacial nerve
Zygomaticotemporal foramen	Lateral wall	Zygomaticotemporal nerve
Anterior ethmoidal foramen	Ethmoidal bone	Anterior ethmoidal nerve
Posterior ethmoidal foramen	Ethmoidal bone	Posterior ethmoidal nerve

EYELIDS AND LACRIMAL APPARATUS

Eyelids and tears (lacrimal fluid) protect cornea and eyeball from dust and particulate matter.

Eyelids

- Two moveable folds of skin that cover the eye anteriorly
- Protect the eye from injury and excessive light and keep corneas moist
- Eyelids separated by an elliptical opening, the palpebral fissure
- Covered by thin skin externally and palpebral conjunctiva internally
  - Palpebral conjunctiva continuous with bulbar conjunctiva of eyeball
  - Lines of reflection of palpebral conjunctiva onto eyeball are deep recesses: superior and inferior conjunctival fornices
- Strengthened by plates of dense connective tissue: tarsal plates
  - Tarsal glands embedded in plates
  - Produce a lipid secretion
    - Lubricates edge of eyelids to prevent them from sticking together
    - Barrier for lacrimal fluid
- Medial palpebral ligaments
  - Attach tarsal plates to medial margin of orbit
  - Orbicularis oculi attaches to this ligament
- Lateral palpebral ligaments attach tarsal plates to lateral margin of orbit
- Orbital septum from tarsal plates to margins of orbit, continuous with periosteum of bony orbit
- Skin around the eyes devoid of hair except for eyelashes
  - Are arranged in double or triple rows on the free edges of the eyelids
  - Ciliary glands associated with eyelashes: sebaceous glands
- Muscles of the eyelids
  - Orbicularis oculi
  - Levator palpebrae superioris

Lacrimal Apparatus

- Functions
  - Secretes tears
  - Prevents desiccation of cornea and conjunctiva
  - Lubricates eye and eyelid
  - Antibacterial
- Consists of
  - Lacrimal glands
  - Lacrimal ducts

- Lacrimal canaliculi
- Nasolacrimal ducts
- Lacrimal gland
  - Lies in fossa for lacrimal gland in superolateral orbit
  - Consists of two parts
    - Larger orbital
    - Smaller palpebral
  - Divided by expansion of tendon of levator palpebrae superioris
  - Twelve lacrimal ducts open from deep surface of gland into superior conjunctival fornix.
  - Secrete lacrimal fluid upon stimulation by parasympathetic secretomotor fibers from CN VII
- Lacrimal canaliculi
  - Drain tears from lacrimal lake at medial angle of eye
  - Drain to lacrimal sac
- Lacrimal sac drains to nasal cavity via nasolacrimal duct

CONTENTS OF THE ORBIT

Eyeball

- Surrounded by fascial sheath (Tenon's capsule)
  - From optic nerve to junction of cornea and sclera
  - Forms socket
  - Pierced by tendons of extra-ocular muscles
- Three layers
  - Outer fibrous = sclera and cornea
  - Middle vascular = choroid, ciliary body, and iris
  - Inner pigmented and nervous = retina
- Fibrous coat
  - Sclera = opaque part of fibrous coat
    - Covers posterior five sixths of eyeball
    - Visible through conjunctiva is the white of the eye
    - Pierced posteriorly by optic nerve
  - Cornea
    - Transparent part of fibrous coat
    - Transmits light
- Middle vascular layer
  - Choroid
    - Outer pigmented layer
    - Inner vascular layer
    - Lies between sclera and retina
    - Lines most of sclera
    - Terminates anteriorly as ciliary body
  - Ciliary body
    - Connects choroid with iris
    - Contains smooth muscle that alters shape of lens
    - Folds on internal surface (ciliary processes) produce aqueous humor and attach to suspensory ligament of lens
  - Iris
  - Pigmented diaphragm with central aperture: the pupil
  - Contains smooth muscle that alters size of pupil to regulate amount of light entering the eye
  - Radial fibers of dilator pupillae open pupil
  - Circular fibers of sphincter pupillae close pupil
- Inner (retinal) layer
  - Consists of three parts
    - Optic part (1)
      - Receives light
      - Composed of two layers: inner neural layer and outer pigmented layer
      - Inner neural layer contains photosensitive cells: rods for black and white and cones for color.
    - Ciliary and iridial parts (2 and 3)
      - Continuation of pigmented layer plus a layer of supportive cells
      - Cover ciliary body and posterior surface of retina
  - Fundus
    - Is posterior part of eye
    - Contains optic disc = depressed area where optic nerve leaves and central artery of retina enters
    - Optic disc contains no photoreceptors = "blind spot"
  - Macula lutea
    - Small oval area of retina
    - Contains concentration of photoreceptive cones for sharpness of vision
    - Depression in center = fovea centralis, area of most acute vision
  - Neural retina ends anteriorly at ora serrata.
    - Serrated border posterior to ciliary body
    - Termination of light receptive part of retina
  - Vasculature of retina
    - Central artery of retina from ophthalmic artery
    - Retinal veins drain to central vein of retina.
    - Rods and cones receive nutrients directly from vessels in choroid.
- Chambers of the eye
  - Anterior chamber
    - Between cornea anteriorly and iris/pupil posteriorly
    - Contains aqueous humor
  - Posterior chamber
    - Between iris pupil anteriorly and lens and ciliary body posteriorly
    - Contains aqueous humor
  - Vitreous chamber
    - Between lens and ciliary body anteriorly and retina posteriorly
    - Contains vitreous body and vitreous humor

Light refraction.

- Cornea
  - Refracts light that enters eye
  - Transparent and sensitive to touch (ophthalmic nerve = CN V_1)
- Aqueous humor in anterior chamber
  - Refracts light
  - Provides nutrients for cornea
  - Produced by ciliary body
  - Circulates through canal of Schlemm in iridocorneal angle
- Lens
  - Transparent, enclosed in capsule
  - Shape changed by ciliary muscles via suspensory ligaments attached around periphery
  - Convexity varies to adjust for focus on near or far objects.
    - Parasympathetic stimulation of ciliary muscle reduces tension of suspensory ligaments and lens rounds up for near vision.
    - Absence of parasympathetic stimulation relaxes ciliary muscle, increases tension on suspensory ligaments and flattens lens for far vision.

Muscles of the Orbit

- Intrinsic (intra-ocular) muscles
  - Ciliary muscle
  - Constrictor pupillae of iris
  - Dilator pupillae of iris
- Extrinsic (extra-ocular) muscles
  - Six muscles
  - Four arise from common tendineus ring surrounding optic canal and part of superior orbital fissure
    - Lateral and medial rectus (2)
      - Lie in same horizontal plane
      - Rotate eyeball laterally and medially, respectively
    - Superior and inferior rectus (2)
      - Lie in same vertical plane
      - Pull eyeball superiorly and inferiorly, respectively
  - Inferior oblique
    - Works with superior rectus
    - Pulls eyeball superiorly and laterally
  - Superior oblique
    - Works with inferior rectus
    - Pulls eyeball inferiorly and laterally
  - Sheathed by reflection of fascial sheath around eyeball (Tenon's capsule)
    - Medial and lateral check ligaments
      - Triangular expansions of sheath of medial and lateral rectus muscles
      - Attached to lacrimal and zygomatic bones
      - Limit abduction and adduction
    - Suspensory ligament
      - Union of ligaments with fascia of inferior rectus and inferior oblique muscles
      - Forms sling that supports eyeball

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Main Actions	Innervation	Blood Supply
Extrinsic Muscles of the Eyeball					
Superior rectus	Common tendinous ring	Superior aspect of eyeball, posterior to the corneoscleral junction	Elevates, adducts, and medially rotates eyeball	Oculomotor nerve (CN III)—superior division	Ophthalmic artery
Inferior rectus	Common tendinous ring	Inferior aspect of eyeball, posterior to corneoscleral junction	Depresses, adducts, and laterally rotates eyeball	Oculomotor nerve (CN III), inferior division	Ophthalmic artery
Medial rectus	Common tendinous ring	Medial aspect of eyeball, posterior to corneoscleral junction	Adducts eyeball	Oculomotor nerve (CN III), inferior division	Ophthalmic artery
Lateral rectus	Common tendinous ring	Lateral aspect of eyeball, posterior to corneoscleral junction	Abducts eyeball	Abducent nerve (CN VI)	Ophthalmic artery
Superior oblique	Body of sphenoid (above optic foramen), medial to origin of superior rectus	Passes through trochlea and attaches to superior sclera between superior and lateral recti	Abducts, depresses, and medially rotates eyeball	Trochlear nerve (CN IV)	Ophthalmic artery
Inferior oblique	Anterior floor of orbit lateral to nasolacrimal canal	Lateral sclera deep to lateral rectus	Abducts, elevates, and laterally rotates eyeball	Oculomotor nerve (CN III)—inferior division	Ophthalmic artery
Muscles of Eyelids					
Levator palpebrae superioris	Lesser wing of sphenoid, anterior to optic canal	Superior tarsal plate	Raises upper eyelid	Oculomotor nerve (CN III)—superior division	Ophthalmic artery
Orbicularis oculi	Medial orbital margin, palpebral ligament, and lacrimal bone	Skin around orbit, palpebral ligament, upper and lower eyelids	Closes eyelids	Facial nerve (CN VII)	Facial and superficial temporal arteries
Intrinsic Muscles of the Eye					
Sphincter pupillae (iris)	Circular smooth muscle of the iris that passes around pupil	Blends with dilator pupillae fibers	Constricts pupil	Parasympathetic fibers via oculomotor nerve (CN III)	Ophthalmic artery
Dilator pupillae (iris)	Radial fibers in iris	Blends with sphincter pupillae fibers	Dilates pupil	Sympathetic fibers via long ciliary nerves (CN V_1)	Ophthalmic artery
Ciliary muscles	Corneoscleral junction	Ciliary body	Constricts ciliary body and lens rounds up (accommodation)	Parasympathetic fibers via short ciliary nerves (CN V_1)	Ophthalmic artery

Vasculature of the Orbit

- Arteries
  - Ophthalmic artery (main supply)
    - Enters orbit through optic canal
    - Lateral to optic nerve
  - Infra-orbital artery from maxillary
  - Branches of ophthalmic artery
    - Supra-orbital
    - Supratrochlear
    - Lacrimal
    - Dorsal nasal
    - Ethmoidal—anterior and posterior
    - Central artery of retina
      - Branch of ophthalmic
      - Runs within dural sheath of optic nerve
      - Emerges at optic disc and branches over retina
    - Posterior ciliary arteries
      - Branches of ophthalmic
      - Six short to choroid
      - Two long to ciliary plexus
    - Anterior ciliary
      - From muscular branches of ophthalmic
      - Anastomoses with posterior ciliary arteries

Distribution of Branches of Ophthalmic Artery

Branch (in Order of Origin)	Structures Supplied
Lacrimal artery	Lacrimal gland, conjunctiva, and eyelids
Short posterior ciliary arteries	Choroid layer of retina to supply visual layer
Long posterior ciliary artery	Ciliary body and iris
Central artery of retina	Retina
Supra-orbital artery	Forehead and scalp
Posterior ethmoidal artery	Posterior ethmoidal air cells
Anterior ethmoidal artery	Anterior and middle ethmoidal air cells, frontal sinus, nasal cavity, skin of nose
Dorsal nasal	Dorsum of nose
Supratrochlear	Forehead and scalp

- Venous drainage
  - Superior ophthalmic vein
    - Formed by union of supra-orbital and angular vein of face
    - Receives blood from anterior and posterior ethmoidal, lacrimal, and muscular branches, central vein of retina, and upper two vorticose veins of retina
    - Drains to cavernous sinus
  - Inferior ophthalmic vein
    - Forms in floor of orbit
    - Receives blood from lower extra-ocular muscles and lower two vorticose veins of retina
    - Drains to cavernous sinus
    - Communicates with pterygoid plexus of veins through inferior orbital fissure

Innervation of the Orbit

- Optic nerve
  - Formed from axons of retinal ganglion cells
  - Exits through optic canal
  - Fibers from medial half of each retina cross at optic chiasm and join uncrossed fibers from lateral half of contralateral retina to form optic tract.
- Oculomotor nerve (CN III)
  - Runs in lateral wall of cavernous sinus
  - Enters orbit through superior orbital fissure
  - Contains parasympathetic fibers to sphincter pupillae and ciliary muscles
  - Supplies
    - Levator palpebrae superioris
    - Superior rectus
    - Medial rectus
    - Inferior rectus
    - Inferior oblique
- Trochlear nerve (CN IV)
  - Runs in lateral wall of cavernous sinus
  - Passes through superior orbital fissure
  - Supplies superior oblique muscle
- Abducent nerve (CN VI)
  - Courses through cavernous sinus
  - Enters orbit via superior orbital fissure
  - Innervates lateral rectus muscle
- Branches of the ophthalmic nerve (CN V_1)
  - Lacrimal nerve to lacrimal gland
  - Frontal nerve
    - Divides into supra-orbital and supratrochlear
    - Supplies upper eyelid, forehead, and scalp
  - Nasociliary nerve and its branches
    - Infratrochlear to eyelids, conjunctiva, and nose
    - Anterior and posterior ethmoidal nerves to sphenoidal and ethmoidal sinuses and anterior cranial fossa
    - Long ciliary nerves to dilator pupillae
- Short ciliary nerves
  - Branches from ciliary ganglion
  - Carry parasympathetic and sympathetic fibers
  - Innervate ciliary body and iris

CLINICAL POINTS

GENERAL TESTING OF EXTRA-OCULAR MUSCLES

- Extra-ocular muscles act as synergists and antagonists and are responsible for multiple movements of the eye.
- It can be difficult to test each eye muscle individually.
- A generalist, however, can gain a general idea of extra-ocular muscle (or nerve) impairment by checking the ability of individual muscles to elevate or depress the globe with the eye abducted or adducted, thereby aligning the globe with the pull (line of contraction) of the muscle.
- Ask patient to "Follow my finger with just your eyes" and move your finger in the form of the letter H.
- Superior rectus is tested by moving your finger superiorly and medially to the eye (to counteract the interaction of the inferior oblique).
  - Inferior rectus is tested by moving your finger inferiorly and medially to the eye (to counteract the interaction of the superior oblique).

- The medial and lateral rectus muscles are tested by moving your finder medially and laterally to the eye.
- The inferior oblique is tested by moving your finger superiorly and laterally to the eye.
- The inferior oblique is tested by moving your finger inferiorly and laterally to the eye.
- Remember that because all the muscles are involved in the continuous movement of the eye, it is difficult to isolate the action of just one with absolute clinical certainty via this test.

CATARACT

- Most common clinical condition of the eye worldwide
- Involves opacification, or cloudiness, of the lens
- Risk factors include smoking, age, alcohol, diabetes, steroid use, and exposure to ultraviolet (UV) rays.
- Treatment involves surgical removal of the lens.
- Eyesight is corrected with an implant, glasses, and/or contact lens.

GLAUCOMA

- One of most common cause of blindness worldwide
- Buildup of pressure in anterior and posterior chambers of the eye
- Usually a result of resistance to outflow of aqueous humor via angle of eye and through canal of Schlemm
- Results in compression of neural layer of retina
- Leads to visual field defects and ultimately blindness
- Increased intra-ocular pressure classified as open or closed angle
  - Open angle—develops gradually with blocking of canal of Schlemm or obstruction of angle
  - Closed angle—occurs rapidly when iris and lens block passage of aqueous humor through pupil

ORBITAL "BLOW-OUT" FRACTURES

- Medial and inferior walls of orbit are very thin, so a blow to the eye can fracture the orbit.
- Indirect trauma that displaces walls is called a "blow-out" fracture.
- Fractures of medial wall may involve ethmoidal and sphenoidal sinuses.
- Fracture of the floor may involve the maxillary sinus.
- Fractures can result in intraorbital bleeding.
- Blood puts pressure on eyeball, causing exophthalmos.
- Blood and orbital structures can herniate into maxillary sinus.

CONJUNCTIVITIS

- Common condition often referred to as "pink eye"
- An inflammation of the conjunctiva
- Symptoms include redness, irritation, and watering of the eyes and sometimes discharge and itching.
- Can be triggered by infection
- Highly contagious
- Caused by bacteria or viruses
- Sexually transmitted diseases (STDs), such as gonorrhoeae and chlamydia, can cause it.
- Viral conjunctivitis is common with several viral infections and can arise as a result of or during a common cold or flu.
- Can be triggered by allergies
  - More frequently occurs in children with other allergic conditions, e.g., hay fever, animal fur
  - Typically affects both eyes at the same time
- Can be triggered by an external irritant
  - Can be caused by pollutants such as traffic fumes, smoke
  - Can be caused by chemicals such as soap, chlorine

MEMORY AIDS

Formula for the innervation of extra-ocular muscles:
LR6–SO4
Rest 3
LR6 ***L*** *ateral* ***R*** *ectus* → CN VI (abducent)
SO4 ***S*** *uperior* ***O*** *blique* → CN IV (trochlear nerve)
Rest: Remaining 4 muscles → CN III (oculomotor)
Superior rectus
Inferior rectus
Medial rectus
Inferior oblique

1.10 EAR

Study Aims

At the end of your study, you should be able to:

- Define the external, middle, and inner ear
- Describe the anatomical features of the external ear
- Describe the tympanic membrane (eardrum)
- Describe the walls of the middle ear
- Outline the structures located within the middle ear
- Understand the transmission of sound through the middle ear
- Describe the bony labyrinth and its components
- Describe the membranous labyrinth and its components
- Understand the organization of the semicircular canals and their relationship to equilibrium
- Understand the organization of the Organ of Corti and its relationship to hearing
- Understand how sound is perceived

GUIDE

EAR—OVERVIEW

- Divided into three parts
  - External ear
    - Auricle
    - External acoustic meatus
  - Middle ear
    - Tympanic cavity and its contents
    - Epitympanic recess
  - Inner ear
    - Vestibulocochlear organ
    - Membranous labyrinth
    - Bony labyrinth
- Functions are equilibrium (balance) and hearing

External Ear

- Auricle, or pinna
  - Skin-covered elastic cartilage

- Collects sound and directs it to external auditory meatus
- Features
  - Deep depression: concha
  - Lobule: earlobe
- External auditory (acoustic) meatus
  - From deepest part of concha to tympanic membrane
  - Through tympanic part of temporal bone
  - Lateral one third is cartilaginous and lined with normal skin.
  - Medial two thirds are bony and lined with thin skin continuous onto tympanic membrane.
  - Ceruminous glands (wax producing) and sebaceous glands are found in subcutaneous tissue of lateral one third.
- Tympanic membrane
  - Forms medial wall of external ear, lateral wall of middle ear
  - Oval and semitransparent
  - Covered with thin skin externally and mucous membrane internally
  - Has shallow, conelike depression at its center (seen otoscopically) with umbo at center of depression
  - Lateral process (handle) of malleus embedded in tympanic membrane and tip extends to umbo on internal surface
  - Pars tensa
    - Part of membrane below handle of malleus
    - Contains circular and radial fibers
  - Pars flaccida
    - Part of membrane above handle of malleus
    - Contains no fibers
  - Moves in response to air vibrations
  - Transmits vibrations to auditory ossicles of middle ear via handle of malleus

Middle Ear

- Contained within petrous part of temporal bone
- Includes tympanic cavity and epitympanic recess
- Is connected anteriorly with nasopharynx by pharyngotympanic tube (auditory canal)
- Contains
  - Auditory ossicles (bones of middle ear)
    - Malleus (hammer)
    - Incus (anvil)
    - Stapes (stirrups)
  - Stapedius and tensor tympani muscles
  - Chorda tympani nerve
  - Tympanic plexus (nerves)
- Walls of tympanic cavity
  - Roof
    - Thin bone—tegmen tympani
    - Separates tympanic cavity from middle cranial fossa
  - Floor
    - Bony
    - Separates tympanic cavity from superior bulb of internal jugular vein
  - Medial wall
    - Separates tympanic cavity from inner ear
    - Features
      - Promontory: round projection overlying basal turn of cochlea
      - Oval window into which footplate of stapes fits—covered by secondary tympanic membrane
      - Fenestra cochlea or round window
  - Anterior wall
    - Separates tympanic cavity from carotid canal
    - Superiorly has opening of auditory tube and canal for tensor tympani
  - Posterior wall
    - Superiorly, aditus (opening) to mastoid antrum, connecting to mastoid air cells
    - Between posterior wall and aditus, prominence of canal of facial nerve
    - Pyramidal eminence
      - Tiny cone-shaped prominence
      - Contains proximal attachment of stapedius muscle
  - Lateral wall
    - Tympanic membrane
    - Lateral wall of epitympanic recess
    - Handle of malleus
- Ossicles
  - Chain of bones across tympanic cavity
  - Extend from tympanic membrane to oval window on medial wall
    - Handle of malleus attaches to tympanic membrane and head articulates with incus.
    - Incus articulates with head of malleus and end of long limb with stapes.
    - Head of stapes articulates with long limb of incus and base (foot-plate) fits into oval window on medial wall.
  - Increase force but decrease amplitude of vibrations from tympanic membrane
- Pharyngotympanic (auditory) tube
  - Formerly called eustachian tube
  - Communication between middle ear and nasopharynx
  - Allows equalization of atmospheric pressure in middle ear
  - Actively opened by coordinated contractions of levator and tensor veli palatine muscles
- Muscles
  - Function to dampen movement of auditory ossicle
  - Tensor tympani
  - Stapedius
- Nerves
  - Chorda tympani
    - Branch of facial nerve (cranial nerve [CN]) VII
    - Emerges from facial canal through canaliculus in posterior wall of middle cavity
    - Carries taste fibers to anterior two thirds of tongue
    - Crosses medial surface of neck of malleus
    - Exits anteriorly via canaliculus to petrotympanic fissure
  - Tympanic plexus
    - On promontory of medial wall
    - Contributions from tympanic branch of glossopharyngeal (CN IX)
    - Twigs from internal carotid plexus
    - Twig from facial nerve
    - Supplies
      - Mucous membrane of tympanic cavity
      - Mastoid antrum

  - Mastoid air cells
  - Auditory tube

Inner Ear

- Concerned with reception of sound and maintenance of balance
- Buried within petrous portion of temporal bone
- Membranous labyrinth suspended within bony labyrinth
- Bony labyrinth
  - Occupies lateral region of petrous ridge of temporal bone
  - Space filled with perilymph
  - Surrounded by bony capsule harder than petrous bone
  - Cochlea
    - Concerned with hearing
    - Contains membranous cochlear duct
    - Consists of
      - Spiral canal
      - Bony core, the modiolus
    - Canal spirals around modiolus
    - Basal turn forms promontory of medial wall of tympanic cavity
  - At basal turn, bony labyrinth communicates with subarachnoid space above jugular foramen via cochlear aqueduct.
  - Vestibule
    - Small oval chamber
    - Contains membranous utricle and saccule
    - Oval window is on lateral wall
    - Continuous with
      - Cochlea anteriorly
      - Semicircular canals posteriorly
    - Communicates with posterior cranial fossa via aqueduct of vestibule
      - Extends to posterior surface of petrous ridge of temporal bone
      - Contains membranous endolymphatic duct
  - Semicircular canals
    - Anterior, posterior, and lateral
    - Set at right angles to each other in three planes
    - Lie posterosuperior to vestibule
    - Each opens into vestibule
    - Swelling at one end of each canal: ampulla
    - Contain membranous semicircular ducts
- Membranous labyrinth
  - Collection of ducts and sacs
  - Suspended within bony labyrinth
  - Filled with endolymph
  - Vestibular labyrinth
    - Utricle
      - Has specialized area of sensory epithelium: macula
      - Hair cells in macula innervated by vestibular division of vestibulocochlear nerve (CN VIII)
      - Hairs respond to tilting of head and linear acceleration and deceleration.
    - Saccule
      - Communicates with utricle
      - Continuous with cochlear duct
      - Contains macula, identical in structure and function to that of utricle
    - Semicircular ducts
      - Within semicircular canals
      - Each has ampulla at one end
      - Ampullary crest in each ampulla senses movement of endolymph in plane of duct.
      - Hair cells in crest innervated by vestibular division of vestibulocochlear nerve (CN VIII).
      - Detect rotational (tilting) movements of head
  - Cochlear labyrinth
    - Spiral ligament suspends cochlear duct from external wall of spiral canal.
    - Cochlear duct
      - Triangular in shape
      - Filled with endolymph
      - Spans spiral canal, dividing it into two channels, each filled with perilymph
      - Two channels: scala tympani and scala vestibule, meet at apex of cochlea (helicotrema)
      - Third, middle channel = cochlear duct
      - Roof of duct = vestibular membrane
      - Floor of duct = basilar membrane
    - Spiral organ of Corti
      - Found on basilar membrane
      - Covered by gelatinous tectorial membrane
      - Contains hair cells—tips embedded in tectorial membrane
      - Hair cells innervated by cochlear division of vestibulocochlear nerve (CN VIII)
- Propagation of sound
  - Initiated by sound waves
    - Transmitted as vibrations by ossicles
    - Stapes vibrates in oval window
    - Creates waves of pressure in perilymph of vestibule
    - Waves ascend in spiral canal in scala vestibule
    - Transfer to scala tympani at helicotrema
    - Pass down scala tympani to round window
    - Dissipated via secondary tympanic membrane in round window to air of middle ear cavity
  - Reception of sound
    - Deformation of cochlear duct by pressure waves in perilymph
    - Stimulates hair cells of spiral organ embedded in tectorial membrane
    - Base of spiral organ receives high frequency sounds and apex receives low-frequency sounds.
- Internal auditory (acoustic) meatus
  - 1 cm long tiny canal in petrous ridge of temporal bone
  - Opening in posteromedial aspect of ridge in posterior cranial fossa
  - Transmits facial (CN VII) and vestibulocochlear (CN VIII) nerve

CLINICAL POINTS

OTITIS EXTERNA

- Defined as an inflammation or infection of the external ear
- Also called swimmer's ear
- Usually bacterial in origin
- Pathogens include *Pseudomonas aeruginosa* and *Staphylococcus aureus.*
- Patient may present with itchiness, a sensation of having the ear blocked, and pain.
- Ear on examination is painful, erythematous, and may be discharging pus.
- Treatment is with topical antibiotics (eardrops).

OTITIS MEDIA

- Defined as an inflammation of the middle ear
- Also known as glue ear
- Most common in children between the ages of 6 months and 2 years
- Symptoms include pulling or rubbing the ears because of ear pain, fever, fussiness, or irritability, fluid leaking from the ear, changes in appetite or sleeping patterns, trouble hearing.
- Usually the result of bacterial infection
- On examination with an otoscope, eardrum looks dull with loss of the cone of light.
- Commonly treated with antibiotics
- With frequent recurring infections and evidence of hearing loss or speech delay, small tubes (tympanostomy tubes) are placed in the eardrums to ventilate the area behind the eardrum and keep the pressure equalized to atmospheric pressure in the middle ear.

WEBER TEST AND RINNE TEST FOR HEARING

Weber Test

- A tuning fork is struck and placed on the patient's forehead.
- The patient is asked to report in which ear the sound is heard louder.
- This test cannot confirm normal hearing, because hearing defects affecting both ears will equally produce an apparently normal test result.
- A Rinne test should be done at the same time.

Rinne Test

- Compares perception of sounds, as transmitted by air or by sound conduction through the mastoid
- This is achieved by placing a vibrating tuning fork (512 Hz) initially on the mastoid, then next to the ear and asking which sound is loudest.
- A patient with normal hearing with a positive Rinne on both sides would hear the sound equally in both ears or may not even hear it at all if the room is noisy enough to mask the subtle sound of the tuning fork.
- A patient with a unilateral (one-sided) conductive hearing loss would hear the tuning fork loudest in the affected ear (conduction through bone is more effective that the normal route through the outer and middle ear).

1.11 BRAIN AND MENINGES

Study Aims

At the end of your study, you should be able to:

- Outline the gross structure of the brain
- State the lobes of the cerebral hemispheres and their function
- Describe the layers of the meninges
- Outline the venous drainage of the brain and the key venous sinuses
- Describe the formation of cerebrospinal fluid

GUIDE

BRAIN

- Composed of six regions for purposes of description
- (1) Cerebral hemispheres (cerebrum)
  - Largest part of brain
  - Occupy anterior and middle cranial fossae
  - Two, separated by longitudinal cerebral fissure
  - Connected by transverse fiber bundle at base of longitudinal fissure: corpus callosum
  - Cavity in each hemisphere = ventricle
  - Composed of four lobes
    - Frontal lobe
      - Involved in higher mental function
      - Contains speech and language centers
    - Parietal lobe
      - Initiates movement
      - Involved in perception
    - Temporal lobe
      - Involved in memory, hearing, and speech
    - Occipital lobe
      - Contains visual cortex
  - Each lobe marked by folds (gyri) and grooves (sulci)
- (2) Diencephalon
  - Composed of
    - Epithalamus
    - Thalamus
    - Hypothalamus
  - Surrounds third ventricle of brain between right and left halves
- (3) Midbrain (mesencephalon)
  - At junction of middle and posterior cranial fossae
  - Contains narrow canal: cerebral aqueduct
- (4) Pons
  - Found in anterior region of posterior cranial cavity
  - Contains cavity that contributes to fourth ventricle
- (5) Medulla oblongata
  - Lies in posterior cranial fossa
  - Continuous with spinal cord
  - Contains inferior portion of fourth ventricle
- (6) Cerebellum
  - Dorsal to pons and medulla
  - Beneath posterior cerebrum
  - Composed of two lateral hemispheres connected by vermis in midline
  - Important in
    - Maintenance of balance, posture and coordination
    - Timing and strength of contraction of muscles

Brainstem

- Parts of brain hidden by cerebral hemispheres and cerebellum
- Contains third and fourth ventricles and cerebral aqueduct
- Composed of
  - Midbrain
  - Pons
  - Medulla oblongata
- Contains masses of gray matter, many of which are sensory and motor nuclei of cranial nerves

Arterial Supply to the Brain

- Internal carotid artery
  - Arises in neck
  - Enters cranial cavity via carotid canals
  - Terminates as
    - Anterior cerebral artery—connected to opposite artery by anterior communicating artery
    - Middle cerebral artery
  - Joined to posterior cerebral artery near termination by posterior communicating artery
- Vertebral arteries
  - Ascend through transverse foramina of C1–C6 cervical vertebrae
  - Perforate dura
  - Enter posterior cranial fossa via foramen magnum
  - Unite at posterior pons to form basilar artery
  - Ascends on clivus
  - Divides into two posterior cerebral arteries
    - Unite with internal carotid artery via posterior communicating arteries
- Circle of Willis
  - Cerebral arterial circle
  - Composed of
    - Anterior communicating artery
    - Anterior cerebral arteries
    - Internal carotid arteries
    - Posterior communicating arteries
    - Posterior cerebral arteries
- Areas supplied by anterior cerebral artery
  - Medial and superior brain
  - Frontal pole
- Areas supplied by middle cerebral artery
  - Lateral brain
  - Temporal pole
- Posterior cerebral artery
  - Inferior brain
  - Occipital pole

MENINGES

- Surround and protect the brain
- Support for arteries, veins, and venous sinuses
- Enclose subarachnoid space
- Enclose cerebrospinal fluid (CSF)
- Similar in name, structure, and arrangement to those around spinal cord
- Dura mater
  - Thick fibrous layer
  - Consists of two layers (unlike the dura mater around spinal cord)
  - Outer periosteal layer = periosteum on inner surface of calvaria
  - Inner meningeal layer
    - Tightly bound to periosteal layer
    - Continuous with dural of spinal cord
- Arachnoid mater
  - Thin, nonvascular membrane
  - Loosely attached to dura mater
  - Separated from pia mater by subarachnoid space
- Pia mater
  - Adherent to brain and spinal cord
  - Highly vascular connective tissue
- Subarachnoid space
  - Real space between arachnoid and pia mater
  - Contains cerebrospinal fluid from ventricular system—cushions brain
- Subarachnoid cisterns
  - Areas where pia and arachnoid are widely separated
  - Collect large pools of CSF
  - Occur mainly at base of brain

Venous Drainage of Brain

- Cerebral veins
  - Superior and lateral surfaces of brain to superior sagittal sinus
  - On posterior and inferior aspects of brain drain into straight, transverse, and superior petrosal sinuses
  - Thin-walled and valveless
- Superior cerebellar veins to straight, transverse, and superior petrosal sinuses
- From dural venous sinuses to internal jugular vein

Dural Infoldings

- Created by internal meningeal layer of dura mater
- Form septa that separate regions of brain from other regions
- Falx cerebri
  - Largest of infoldings
  - Lies in longitudinal fissure
- Tentorium cerebelli
  - Second largest infolding
  - Crescent-shaped fold separating cerebral hemispheres from cerebellum
  - Attaches
    - Anteriorly to clinoid processes of sphenoid
    - Laterally to petrous part of temporal bone
    - Posteriorly and laterally to internal occipital and parietal bones
    - Falx cerebri, which suspends tentorium
  - Tentorial notch
    - Gap in anterior border
    - Allows for passage of brain stem
- Diaphragma sellae
  - Circular sheet of dura
  - Suspended between anterior and posterior clinoid processes
  - Contains gap for passage of pituitary stalk and accompanying veins

Dural Venous Sinuses

- Endothelium-lined channels between periosteal and meningeal layers of dura
- Thick-walled and valveless
- Formed where dura attaches
- Confluence of sinuses: where superior sagittal, straight, occipital, and transverse sinuses meet at internal occipital protuberance
- Superior sagittal sinus
  - From crista galli to confluence of sinuses
  - Communicates via slitlike openings with lateral venous lacunae
- Inferior sagittal sinus: from crista galli to straight sinus
- Straight sinus: formed by union of inferior sagittal sinus and great cerebral vein (of Galen)

- Transverse sinus
  - Drains confluence of sinuses
  - Runs along posterolateral attachment of tentorium cerebelli
  - Becomes sigmoid sinus
- Sigmoid sinus
  - Traverses jugular foramen
  - Becomes internal jugular vein
- Occipital sinus: at attached border of cerebellar falx
- Cavernous sinus
  - On either side of sella turcica
  - Composed of a network of thin, valveless vein
  - Sinuses communicate with each other via intercavernous sinuses
  - Receives blood from
    - Superior and inferior ophthalmic veins
    - Superficial middle cerebral vein
    - Sphenoparietal sinus
  - Contains
    - Internal carotid artery
    - Oculomotor nerve (CN III)
    - Trochlear nerve (CN IV)
    - V_1 division of trigeminal nerve (CN V)
    - Abducent nerve (CN VI)
    - Sympathetic plexus around artery
- Superior petrosal sinus: from posterior ends of cavernous sinuses to transverse sinuses
- Inferior petrosal sinus: from posterior ends of cavernous sinuses to internal jugular vein
- Emissary veins connect dural sinuses with veins outside cranium

Sinus	Location	Comment	Drains to
Superior sagittal sinus	Upper border falx cerebri	1. Drains cerebral veins 2. Contains arachnoid villi and granulations for reabsorption CSF	Confluence of sinuses
Inferior sagittal sinus	Lower free margin falx cerebri		Joins great cerebral vein forming straight sinus
Straight sinus	Junction falx cerebri and tentorium cerebelli	Formed by union great cerebral vein with inferior sagittal sinus	Confluence of sinuses
Transverse sinus	Lateral margin tentorium cerebelli	1. Passes laterally from confluence of sinuses 2. Left is usually larger	Sigmoid sinus
Sigmoid sinus	S-shaped course in temporal and occipital bones	Continuation transverse sinus	Internal jugular vein
Cavernous sinus	Superior surface of body of sphenoid, lateral to sella turcica	1. Receives superior and inferior ophthalmic and superficial middle cerebral veins and sphenoparietal sinus 2. Contains internal carotid artery and CN III, IV, V1, and V_l, sympathetic nerves	Superior and inferior petrosal sinuses
Intercavernous sinus	Runs through sella turcica	Connects cavernous sinuses	
Superior petrosal sinus	Margin tentorium cerebelli attached to petrous temporal bone	Connects cavernous sinus to transverse sinus	Transverse sinus
Inferior petrosal sinus	Medial border petrous temporal bone to jugular foramen	Connect cavernous sinus to internal jugular vein	Internal jugular vein

Cerebrospinal Fluid (CSF)

- Maintains balance of extracellular fluid in the brain
- Similar in content to blood
  - Less protein
  - Different ion concentrations
- Formed by choroids plexuses in four ventricles of the brain
- Are plexuses of capillaries that project into lateral, third and fourth ventricles
- Circulates through ventricular system
  - From lateral ventricles to interventricular foramina to third ventricle
  - From third ventricle through cerebral aqueduct to fourth ventricle
  - From fourth ventricle through paired lateral apertures and a single midline aperture in roof into subarachnoid space
- Absorbed through arachnoid granulations into venous blood in dural venous sinuses
  - Arachnoid granulations are tufts of arachnoid villi protruding into dural venous sinuses.
  - Subarachnoid space with CSF extends into core of tufts
  - Approximately 400 mL/day of CSF → venous circulation

Vasculature of Dura

- Primarily provides blood to calvaria
- Middle meningeal artery
  - Branch of axillary artery
  - Enters through foramen spinosum
  - Anterior and posterior branches
- Meningeal branches of
  - Ophthalmic arteries
  - Occipital arteries
  - Vertebral arteries
- Venous drainage: meningeal veins
  - Accompany meningeal arteries
  - Occur in pairs

- Frequently torn in skull fractures
- Middle meningeal veins drain to pterygoid venous plexus

CLINICAL POINTS

MENINGITIS

- Inflammation of the arachnoid and pia mater
- Can be caused by drugs or malignancy, but usually by pathogenic bacteria
- Infection can be due to meningococcal or pneumococcal bacteria.
- Patient may present with fever, nonblanching purpuric rash, neck stiffness, and photophobia.
- Mortality from bacterial causes can be up to 30%.
- Diagnosis is by examination and lumbar puncture.

HYDROCEPHALUS

- Caused by excess cerebrospinal fluid (CSF) production or, more likely, by abnormal absorption
- Classified as obstructive, communicating, or normal pressure
- Blockage usually in cerebral aqueduct by narrowing
- Can be a result of tumor, hemorrhage, and infection
- Can be caused by absence of arachnoid granulations or subarachnoid hemorrhage
- Dilates ventricles, thins cerebral cortex, separates bones of calvaria in infants

BRAIN TUMORS

- 25% of all brain tumors arise from a different site (metastasis).
- Common sites of original tumor include breast, bronchus, prostate, thyroid, and kidney.
- Primary brain tumors can be benign, such as meningiomas and neurofibromas, or malignant, such as astrocytomas and oligodendrogliomas.
- Can present as epilepsy, focal neurology, or signs of raised intracranial pressure
- Diagnosis is by history, examination, and computed tomography (CT) or magnetic resonance imaging (MRI) of the brain.

1.12 CRANIAL AND CERVICAL NERVES

Study Aims

At the end of your study, you should be able to:

- Know the names and functions of the cranial nerves
- State the foramen through which the cranial nerves emerge from the skull
- Outline formation of the cervical plexus
- Know the sensory nerves arising from the cervical plexus and their distribution
- Know the muscles innervated by motor branches of the cervical plexus
- Understand the formation of the ansa cervicalis and know the muscles innervated by its branches
- Describe the formation of, and fibers composing, the phrenic nerve
- Know the structures innervated by the various components of the phrenic nerve

GUIDE

CRANIAL NERVES

Twelve pairs of cranial nerves arise from the brain, and they are identified both by their names and by Roman numerals I through XII.

The cranial nerves are somewhat unique and can contain multiple functional components.

- General: same general functions as spinal nerves
- Special: functions found only in cranial nerves
- Afferent and efferent: sensory or motor functions, respectively
- Somatic and visceral: related to skin and skeletal muscle (somatic), or to smooth muscle and glands (visceral)

Each cranial nerve can have multiple functional components.

- General somatic afferents (GSA)
  - Contains nerve fibers that are sensory from skin, not unlike those of spinal nerve
- General visceral efferents (GVE)
  - Contains motor fibers to visceral structures (smooth muscle and/or glands) like a parasympathetic fiber from sacral spinal cord (S2–S4 gives rise to parasympathetics)
- Special somatic afferents (SSA)
  - Contains special sensory fibers, such as those for vision or hearing

In general, CN I and II arise from the forebrain and are really tracts of the brain for the special senses of smell and sight. CN III, IV, and VI move the extra-ocular skeletal muscles of the eyeball. CN V has three divisions: V_1 and V_2 are sensory, and V_3 is both motor to skeletal muscle and sensory. CN VII, IX and X are both motor and sensory. CN VIII is the special sense of hearing and balance. CN XI and XII are motor to skeletal muscle. CN III, VII, IX, and X also contain parasympathetic fibers of origin (visceral), although many of the ANS fibers will "jump" onto the branches of CN V to reach their targets. The following table summarizes the types of fibers in each cranial nerve and where each passes through the cranium.

Cranial Nerve	Functional Component	Cranial Opening
I Olfactory nerve	SVA (special sense of smell)	Foramina in cribriform plate
II Optic nerve	SSA (special sense of sight)	Optic canal
III Oculomotor nerve	GSE (motor to extra-ocular muscles) GVE (parasympathetic to smooth muscle in eye)	Superior orbital fissure
IV Trochlear nerve	GSE (motor to 1 extra-ocular muscle)	Superior orbital fissure
V Trigeminal nerve	GSA (sensory to face, orbit, nose, anterior tongue) SVE (motor to skeletal muscles)	Three branches (ophthalmic, maxillary, and mandibular) travel through multiple openings
VI Abducens nerve	GSE (motor to 1 extra-ocular muscle)	Superior orbital fissure
VII Facial nerve	GSA (sensory to skin of ear) SVA (special sense of taste to anterior tongue) GVE (motor to glands—salivary, nasal, lacrimal) SVE (motor to facial muscles)	Internal acoustic meatus Facial canal Stylomastoid foramen
VIII Vestibulocochlear nerve	SSA (special sense of hearing and balance)	Internal acoustic meatus
IX Glossopharyngeal nerve	GSA (sensory to posterior tongue) SVA (special sense of taste—posterior tongue) GVA (sensory from middle ear, pharynx, carotid body, and sinus) GVE (motor to parotid gland) SVE (motor to one muscle of pharynx)	Jugular foramen
X Vagus nerve	GSA (sensory external ear) SVA (special sense of taste—epiglottis) GVA (sensory from pharynx, larynx, and thoracic and abdominal organs) GVE (motor to thoracic and abdominal organs) SVE (motor to muscles of pharynx/larynx)	Jugular foramen
XI Spinal accessory nerve	SVE (motor to two muscles)	Jugular foramen
XII Hypoglossal nerve	GSE (motor to tongue muscles)	Hypoglossal canal

- Cranial nerves emerge through foramina or fissures in cranium
- Twelve pairs
- Numbered in order of origin from the brain and brain stem, rostral to caudal
- Contain one or more of six different types of fibers
  - Motor fibers to voluntary muscles
    - Somatic motor fibers to striated muscles (1)
      - Orbit
      - Tongue
      - Neck (sternocleidomastoid and trapezius)
    - Branchial motor (or special visceral efferent fibers) to striated muscles derived from pharyngeal arches (e.g., muscles of mastication) (2)
  - Motor fibers to involuntary muscles = general visceral efferent (parasympathetic fibers) (3)
  - Sensory fibers
    - General visceral afferent fibers (4)
      - Carry sensation from viscera
      - Originate in carotid body, sinus, heart, lungs, and gastrointestinal tract
    - General somatic afferent fibers carrying pain, pressure, temperature, touch information (5)
    - Special sensory afferent fibers conveying taste, smell, vision, hearing, and balance (6)
- Can be sensory, motor, or mixed

Sensory Innervation of the Dura

- Dura of cranial fossae innervated by meningeal branches of cranial and cervical nerves
- Anterior cranial fossa
  - Anterior meningeal branches of ethmoidal nerves from ophthalmic nerves (CN V_1)
  - Meningeal branches of maxillary nerves (cranial nerve [CN] V_2)
  - Meningeal branches of mandibular nerves (CN V_3)
- Middle cranial fossa
  - Meningeal branches of maxillary nerves (CN V_2)
  - Meningeal branches of mandibular nerves (CN V_3)
- Posterior cranial fossa
  - Tentorial nerve from ophthalmic nerve (CN V_1)
  - Meningeal branches directly from C2 and C3 spinal nerves or carried by CN X (vagus) or CN XII (hypoglossal)

Cervical Plexus

- Formed from anterior rami of C1–C4 spinal nerves
- Consists of a series of loops and branches from the loops
- Lies deep to sternocleidomastoid (SCM) and anteromedial to levator scapulae and middle scalene muscles
- Cutaneous branches of cervical plexus
  - Emerge from posterior border of SCM
  - Nerves from loop formed between anterior rami of C2 and C3
    - Lesser occipital (C2) to skin of neck and scalp posterior to auricle
    - Great auricular (C2 and C3) to skin over parotid gland, mastoid process, auricle, and between angle of mandible and mastoid process

    - Transverse cervical nerve (C2 and C3) to skin over anterior cervical region
  - Supraclavicular nerves
    - Arise from C3–C4 loop
    - Emerge from under SCM
    - Supply skin over clavicle, superior thoracic wall, and shoulder
- Motor branches
  - Considered deep branches
  - Innervate prevertebral muscles
    - Sternocleidomastoid (C2 and C3)
    - Trapezius (C3 and C4)
    - Levator scapulae (C3 and C4)
  - Motor fibers from C1 travel with hypoglossal nerve
    - Some C1 fibers leave hypoglossal nerve and innervate
      - Thyrohyoid muscle
      - Geniohyoid muscle
    - Rest leave hypoglossal as its descending branch
  - Motor fibers from C1 and C2 directly innervate thyrohyoid (an infrahyoid strap muscle)/
  - Motor fibers from C2, 3 form descending cervical nerve
  - Ansa cervicalis
    - Loop formed by descending branch from hypoglossal nerve (superior root) (C1) and descending cervical nerve (inferior root) (C2,C3)
    - Branches from ansa innervate remaining infrahyoid strap muscles/
      - Omohyoid
      - Sternohyoid
      - Sternothyroid
  - Motor fibers from C3, C4, and C5 contribute to roots of phrenic nerve/
- Phrenic nerve
  - Formed by branches of anterior rami of C3, C4, and C5 spinal nerves
  - Contains a mix of fibers
    - Sole motor supply to diaphragm
    - Sensory fibers from central part of diaphragm (sensory fibers from periphery provided by intercostal nerves)
    - Sympathetic nerve fibers from cervical sympathetic ganglia to smooth muscle of blood vessel walls

CLINICAL POINTS

FACIAL NERVE PALSY

- Unilateral (one-sided) injury to the facial nerve or its branches
- Results in sudden weakness affecting some or all of facial muscles on affected side
- Causes include infections such as TB, polio; brainstem lesions; tumors, such as acoustic neuromas; acute and sudden exposure of the face to cold temperatures.
- Angle of mouth droops on affected side with dribbling of food and saliva.
- Sad look when face is relaxed
- Lower eyelid falls away from eyeball with drying of cornea and tearing from corner of eye.
- Speech affected (production of B, M, P, and W sounds) because of weakened lip muscles.

TRIGEMINAL NEURALGIA

- Disease affecting the sensory root of CN V
- Characterized by episodes of intense pain lasting a few seconds in areas innervated by the trigeminal nerve.
- Usually one-sided and can affect a division of CN V, usually the mandibular, maxillary nerve.
- Pain can be triggered by touching a sensitive area ("trigger point").
- Cause is not usually known.
- Treatment is directed to controlling the pain.

OCULAR NERVE PALSY

- A lesion of the oculomotor nerve paralyzes all extraocular muscles except the lateral rectus and the superior oblique. This leads to:
- Ptosis—drooping of the eyelid (levator palpebrae superioris)
- No constriction of the pupil in response to light (sphincter pupillae)
- Dilation of the pupil (unopposed dilator pupillae)
- Eyeball abducted and depressed ("down and out") (unopposed lateral rectus and superior oblique)
- No accommodation of the lens for near vision (ciliary muscle)

MEMORY AIDS

Names of the Cranial Nerves

"**O**n **O**ld **O**lympus **T**owering **T**ops **A** **F**ew **V**irile **G**ermans **V**iewed **A**mple Of **H**ops"

I:	**O**n	**O**lfactory
II:	**O**ld	**O**phthalmic
III:	**O**lympus	**O**culomotor
IV:	**T**owering	**T**rochlear
V:	**T**ops	**T**rigeminal
VI:	**A**	**A**bducent
VII:	**F**ew	**F**acial
VIII:	**V**irile	**V**estibulocochlear
IX:	**G**ermans	**G**lossopharyngeal
X:	**V**iewed	**V**agus
XI:	**A**mple	**A**ccessory
XII:	**H**ops	**H**ypoglossal

Motor, Sensory and Mixed (Both) Cranial Nerves

"**S**ome **S**ay **Ma**rry **M**oney **B**ut **M**y **B**rother **S**ays **Ba**d **B**usiness **M**arry **M**oney"

I:	Olfactory	**S**ensory
II:	Optic	**S**ensor
III:	Oculomotor	**M**otor
IV:	Trochlear	**M**otor
V:	Trigeminal	**B**oth
VI:	Abducent	**M**otor
VII:	Facial	**B**oth
VIII:	Vestibulocochlear	**S**ensory
IX:	Glossopharyngeal	**B**oth
X:	Vagus	**B**oth
XI:	Accessory	**M**otor
XII:	Hypoglossal	**M**otor

1.13 CEREBRAL VASCULATURE

Study Aims

At the end of your study, you should be able to:

- State the main arteries that supply the brain
- Describe the course of the vertebral artery
- Identify the arteries contributing to the circle of Willis
- Identify the regions that each of the cerebral arteries supplies
- Describe the venous drainage of the brain
- Identify the branches of the external carotid artery and structures supplied
- Describe the division of the subclavian artery by scalene anterior and the branches given off by each part
- Understand the organization and major vessels of the venous drainage of the head and neck
- Understand the principles and organization of the lymphatic drainage of the face and head and neck
- Understand the principles and organization of the lymphatic drainage of the neck

GUIDE

VASCULAR SUPPLY TO THE BRAIN

Arterial Supply

Internal Carotid Arteries.

- Arise from common carotid arteries in neck
- Begin at upper border of thyroid cartilage
- Have no branches to face or neck
- Enter carotid canals in temporal bone, then pass anteriorly and medially
- Run through carotid sinuses in grooves on side of body of sphenoid
- Terminal branches
  - Anterior cerebral artery
  - Middle cerebral artery
- Contribute to circle of Willis
  - United to posterior cerebral artery by posterior communicating branches
  - Complete arterial circle around interpeduncular fossa
- Provide anterior circulation of brain

Vertebral Arteries.

- First branches of subclavian arteries
- Ascend in foramina transversaria of first six cervical vertebrae
- Provide vascular supply to cervical spinal cord and neck
- Pierce dura and enter cranium via foramen magnum
- Unite at caudal end of pons to form basilar artery
  - Ascends on clivus
  - Terminates by dividing into two posterior cerebral arteries
  - Contributes to circle of Willis
  - Posterior cerebral arteries unite with anterior cerebral arteries via posterior communicating arteries
  - Provides posterior circular of brain

Cerebral Arteries.

- Each supplies a region of the brain
- Anterior cerebral artery
  - Medial and upper lateral surfaces of cerebral hemisphere
  - Frontal pole
- Middle cerebral artery
  - Lower and lateral cerebral hemisphere
  - Temporal pole
- Posterior cerebral artery
  - Inferior surface of cerebral hemisphere
  - Occipital pole

Cerebral Arterial Circle (Circle of Willis).

- Lies in subarachnoid space
- Important anastomosis at base of brain
- Formed by
  - Anterior communicating arteries
  - Anterior cerebral arteries
  - Internal carotid arteries
  - Posterior communicating arteries
  - Posterior cerebral arteries
- Components supply brain via many small branches

Artery	Course and Structures Supplied
Vertebral	From subclavian artery, supplies cerebellum
Posterior inferior cerebellar	From vertebral artery, goes to posteroinferior cerebellum
Basilar	From both vertebrals, goes to brainstem, cerebellum, cerebrum
Anterior inferior cerebellar	From basilar, supplies inferior cerebellum
Superior cerebellar	From basilar, supplies superior cerebellum
Posterior cerebral	From basilar, supplies inferior cerebrum, occipital lobe
Posterior communicating	Cerebral arterial circle (of Willis)
Internal carotid (IC)	From common carotid, supplies cerebral lobes and eye
Middle cerebral	From IC, goes to lateral aspect of cerebral hemispheres
Anterior communicating	Cerebral arterial circle (of Willis)
Anterior cerebral	From IC, goes to cerebral hemispheres (except occipital lobe)

Venous Drainage

- Dural venous sinuses
  - Drain venous blood from superficial and deep veins of the brain
  - Sinuses drain to internal jugular vein via jugular foramen
- Veins on superior and lateral surfaces of brain drain to superior sagittal sinus.
- Basal veins run laterally and dorsally around cerebral peduncle to end in great vein of Galen, which drains to straight sinus.

- Veins on posterior and inferior surfaces of brain, superior cerebellar veins, and transverse sinuses drain to several sinuses.
  - Straight
  - Transverse
  - Superior petrosal

VASCULAR SUPPLY TO SCALP, FACE, AND NECK

Arterial Supply

Common Carotid Artery.

- Branch of aortic arch on left
- Branch of brachiocephalic artery on right
- Ascends neck in carotid sheath, beneath anterior border of sternocleidomastoid
- Bifurcates into internal and external carotid arteries at level of thyroid cartilage
- Internal carotid artery has no branches in neck.

External Carotid Artery.

- Begins in upper border thyroid cartilage
- Mainly supplies the face and structures external to the skull, with some branches to the neck
- Branches
  - Ascending pharyngeal
    - Ascends on pharynx
    - Send branches to pharynx, prevertebral muscles, middle ear, and cranial meninges
  - Superior thyroid
    - Supplies thyroid gland, infrahyoid muscles, and sternocleidomastoid muscle
    - Gives rise to superior laryngeal artery supplying larynx
  - Lingual
    - Passes deep to hypoglossal nerve, stylohyoid muscle, and posterior belly of digastric
    - Disappears beneath hyoglossus muscle and becomes deep lingual and sublingual arteries
  - Facial
    - Branches to tonsil, palate, and submandibular gland
    - Hooks around middle of mandible and enters face
  - Occipital
    - Passes deep to posterior belly of the digastric
    - Grooves base of skull
    - Supplies posterior scalp
  - Posterior auricular
    - Passes posteriorly between external acoustic meatus and mastoid process
    - Supplies muscles of region, parotid gland, facial nerve, auricle, and scalp
  - Maxillary
    - Larger of two terminal branches
    - Branches supply external acoustic meatus, tympanic membrane, dura mater and calvaria, mandible, gingivae and teeth, temporal pterygoid, masseter, and buccinator muscles.
  - Superficial temporal
    - Smaller terminal branch
    - Supplies temporal region of scalp

Carotid Branch	Course and Structures Supplied
Superior thyroid	Supplies thyroid gland, larynx, and infrahyoid muscles
Ascending pharyngeal	Supplies pharyngeal region, middle ear, meninges, and prevertebral muscles
Lingual	Passes deep to hyoglossus muscle to supply the tongue
Facial	Courses over the mandible and supplies the face
Occipital	Supplies sternocleidomastoid (SCM) and anastomoses with costocervical trunk
Posterior auricular	Supplies region posterior to ear
Maxillary	Passes into infratemporal fossa (described later)
Superficial temporal	Supplies face, temporalis muscle, and lateral scalp

Subclavian Artery.

- Branch of aortic arch on left
- From brachiocephalic trunk on right
- Enters neck between anterior and posterior scalene muscles
- Supplies upper limbs, neck, and brain
- Divided for descriptive purposes into three parts, in relation to anterior scalene muscle
  - First part
    - Medial to anterior scalene
    - Three branches
  - Second part
    - Posterior to anterior scalene
    - One branch
  - Third part
    - Lateral to anterior scalene
    - One branch

Subclavian Branch	Course
Part 1	
Vertebral	Ascends through C6–C1 transverse foramina and enters foramen magnum
Internal thoracic	Descends parasternally to anastomose with superior epigastric artery
Thyrocervical trunk	Gives rise to inferior thyroid, transverse cervical, and suprascapular arteries
Part 2	
Costocervical trunk	Gives rise to deep cervical and superior intercostal arteries
Part 3	
Dorsal scapular	Is inconstant; may also arise from transverse cervical artery

Venous Drainage

Superficial Veins.

- External jugular vein (EJV)
  - Drains most of scalp and side of face
  - Formed at angle of mandible by union of retromandibular vein with posterior auricular vein
  - Enters posterior triangle and pierces fascia at its roof
  - Descends to terminate in subclavian vein
  - Receives
    - Transverse cervical vein
    - Suprascapular vein
    - Anterior jugular vein
- Anterior jugular vein
  - Descends deep to investing fascia
  - Posterior to sternocleidomastoid (SCM), drains to EJV or subclavian vein
  - Commonly unites with anterior jugular on opposite side via a jugular venous arch

Deep Veins.

- Internal jugular vein (IJV)
  - Most veins in anterior neck are tributaries of IJV.
  - Drains blood from brain, anterior face, cervical viscera, and deep muscles of neck
  - Begins as dilation of superior bulb just below jugular foramen
  - Runs inferiorly in carotid sheath
  - Inferior end deep to gap between two heads of SCM muscle
  - Joins subclavian vein to form brachiocephalic vein
- Subclavian vein
  - Major vein draining upper limb
  - Passes anterior to anterior scalene muscle
  - Unites at medial border of muscle with IJV to form brachiocephalic vein
- Tributaries of subclavian and IJV travel with arteries of same name.

Lymphatic Drainage

Drainage of Face and Head.

- Superficial lymphatic vessels accompany veins.
- Deep lymphatic vessels accompany arteries.
- Lymphatic drainage of face
  - Drainage from lateral face to parotid nodes
  - Drainage from upper lip and lateral lower lateral lip to submandibular nodes
  - Drainage from chin and central lower lip to submental nodes
- All drain to parotid, mastoid, or superficial cervical nodes
- These drain to deep cervical nodes.

Drainage of Neck.

- Superficial drainage to superficial cervical nodes
  - Located along course of EJV
  - Also receive drainage from nodes of face and head
- Superficial cervical nodes drain to deep cervical nodes.

Deep Cervical Nodes.

- Lie along course of IJV, transverse cervical artery, and accessory nerve
- Include
  - Prelaryngeal nodes
  - Pretracheal nodes
  - Paratracheal nodes
  - Retropharyngeal nodes
- Drain to jugular lymphatic trunk

Jugular Lymphatic Trunks.

- On left
  - Joins thoracic duct on left
  - Thoracic duct enters junction of IJV and subclavian vein.
- On right
  - Empties directly into IJV or brachiocephalic vein
  - Or forms short right lymphatic duct which enters either of these vessels

CLINICAL POINTS

STROKE

- Focal neurology lasting greater than 24 hours as a result of a vascular cause
- Can be caused by an intracranial bleed
- More often (80% of cases) as a result of an infarct—ischemia, because of thrombosis or embolization from an atherosclerotic vessel
- Majority of strokes occur in the territory supplied by the internal carotid artery.
- Symptoms include hemiparesis, hemiplegia, aphasia, homonomous hemianopia.
- Strokes affecting the territory supplied by the vertebral artery can present with ataxia, dysphonia, dysphagia, and homonomous hemianopia.

BERRY ANEURYSM

- Congenital defect in tunica media of arteries of circle of Willis
- Results in a saccular or Berry aneurysm
- Rupture is most common cause of subarachnoid hemorrhage.
- Anterior cerebral, internal carotid, and middle cerebral are most commonly affected.
- Patient may present with headache, vomiting, altered consciousness, and signs of meningeal irritation.

2 Back and Spinal Cord Study Guide

2.1 TOPOGRAPHIC ANATOMY

Study Aims

At the end of your study, you should be able to:

- Identify posteromedian furrow
- Identify external occipital protuberance, vertebra prominens, iliac crests, posterior superior iliac spines
- Identify deltoid, latissimus dorsi, trapezius, erector spinae, teres major, infraspinatus, gluteus maximus, and gluteus medius
- Identify margins of scapula

GUIDE

- Median line of back: posteromedian furrow overlies tips of spinous processes
  - Deepest in lower thoracic/upper lumbar region
  - Bordered by erector spinae
- Vertebra prominens = C7 spinous process *(T1 may be more prominent)*
- Scapula
  - Superior angle at level of T2
  - Medial end of scapular spine opposite spinous process of T3
  - Inferior angle at level of T7
  - Medial border of scapula parallels sixth rib and approximates oblique fissure of lung when arm is abducted by placing hand on head.
- Iliac crests at level of L4 = supracristal line
- S2 spinous process lies level with a line joining posterior superior iliac spines.
- Tip of coccyx approximately 2.5 cm posterosuperior to anus

Anatomy of muscles of the back are covered in *Section 2.4, Muscles and Nerves.* (Muscles that are readily visible are trapezius, latissimus dorsi, and teres major.)

Vertebrae and Corresponding Structures

Level	Corresponding Structure
C2–C3	Mandible
C3	Hyoid bone
C4–C5	Thyroid cartilage
C6	Cricoid cartilage
C7	Vertebra prominens
T3	Spine of scapula
T4/5	Sternal angle (of Louis)
T7	Inferior angle of scapula
T8	Inferior vena cava pierces diaphragm
T10	Xiphisternal junction
T10	Esophagus enters stomach
T12	Aorta passes behind diaphragm
L1/2	Spinal cord ends *(cauda equina starts)*
L3	Subcostal plane
L3–L4	Umbilicus
L4	Bifurcation of aorta
L4	Iliac crests—supracristal line
S2	End of dural sac
S2	Level of posterior superior iliac spines

CLINICAL POINTS

LUMBAR PUNCTURE

Lumbar puncture is performed for retrieval of cerebrospinal fluid (CSF) from the lumbar spinal cistern. The patient is placed in the left decubitus position, flexed in the fetal posture with the supracristal line vertical. Puncture should be made at the L3/4 (immediately superior) or L4/5 (immediately inferior) interspace in the midline of the back, to avoid the spinal cord.

MEMORY AIDS

Lumbar puncture: To keep the cord alive, keep the needle between L3 and L5!

2.2 BONES AND LIGAMENTS

Study Aims

At the end of your study, you should be able to:

- Identify the significant parts of a typical vertebra and understand regional variations
- Identify the specialized vertebrae
- Know the attachments and function of the vertebral ligaments
- Describe the spine, its curvatures, and gross vertebral column movements
- Describe the type, location, and movements of the joints of the vertebral column

GUIDE

VERTEBRAL COLUMN

- Approximately 72 to 75 cm long (25% of length because of intervertebral discs)
- 33 vertebrae *(can vary, 32–34)*
  - 7 cervical, 12 thoracic, 5 lumbar, 5 sacral, 4 (3–5) coccygeal
  - Typically have body; vertebral arch (2 laminae, 2 pedicles) and foramen; spinous (1) and transverse (2) processes; articular processes (4)
- Fibrocartilaginous intervertebral discs
  - Allow movement between vertebral bodies (in cervical, thoracic, and lumbar regions)
- Curvature (may be primary or secondary—see below)
  - Cervical anterior convexity *(2°)*
  - Thoracic anterior concavity *(1°)*
  - Lumbar anterior convexity *(2°)*
  - Sacral anterior concavity *(1°)*

VERTEBRAE

Cervical Vertebrae

- Permit forward/lateral flexion, extension, rotation
- C1 (atlas): No body or spinous process; articulates with occipital condyles via paired lateral masses and with axis via superior articular facets and dens of axis; groove on superior aspect of posterior arch for vertebral arteries and dorsal ramus of C1
- C2 (axis): Dens (odontoid process), large superior articular facets for C1
- C3–C5: Short bifid spinous processes *(anterior tubercle of C6 is carotid tubercle, which carotid artery can be compressed against to control bleeding)*
- C6–7: long, nonbifid spinous processes
- C7 (vertebra prominens): long *(nonbifid)* spinous process; small transverse foramina that transmit accessory vertebral veins NOT vertebral artery
- Have transverse processes with anterior and posterior tubercles and foramina (foramina transversaria) that transmit vertebral arteries and veins and sympathetic nerves plexuses

Thoracic Vertebrae

- Relatively rigid, mainly allow rotation of trunk
- T1–T4: Atypical—have some features of cervical vertebrae
- T5–T8: Typical
- T9–T12: Atypical—have tubercles similar to mammillary and accessory processes of lumbar vertebrae
- Have long transverse processes that extend posterolaterally

Lumbar Vertebrae

- Relatively mobile, permit forward/lateral flexion and extension but little rotation
- Have accessory process found on posterior surface of base of each transverse process for attachment of medial intertransverse lumborum muscle
- Have mammillary process for attachment of multifidus and medial intertransverse muscles
- L5: massive body and transverse processes and is thicker anteriorly—contributes to lumbosacral angle (usually 130°–160°) and carries weight of upper body

Sacrum (Sacral Vertebrae)

- Composed of five vertebrae that fuse at about 20 years of age, inferior portion is nonweightbearing
- Articulates with "hip" bones at sacro-iliac joints
- Has concave pelvic surface
- Is wider in females than males
- Has a sacral canal (continuation of vertebral canal) that contains cauda equine
- Has the following features
  - Sacral hiatus (termination of sacral canal) that contains filum terminale
  - Median crest: fused spinous processes
  - Paired medial crests: fused articular processes
  - Paired lateral crests: fused tips of transverse processes
  - Sacral cornua that project inferiorly on either side of sacral hiatus

Coccyx (Coccygeal Vertebrae)

- Consist of three to five coccygeal vertebrae, inferior three fuse as coccyx in midlife
- Has coccygeal corneae that articulate with sacral cornua
- Provides site of attachment for gluteus maximus, coccygeus muscles, and anococcygeal ligament
- Is joined to sacrum by sacrococcygeal symphysis

Summary of Vertebral Characteristics

Vertebrae	Distinctive Features
Cervical	Small bodies, large vertebral foramina, foramina in transverse processes, anterior and posterior tubercles, bifid spinous processes
Thoracic	Heart-shaped bodies, long spinous processes angled posteroinferiorly; costal facets for rib articulation on bodies and transverse processes

Vertebrae	Distinctive Features
Lumbar	Large kidney-bean-shaped bodies, sturdy laminae, thick and short spinous processes, mammillary processes on posterior surface of superior articular facets (processes)
Sacral	Fused as sacrum, four pairs of dorsal and ventral foramina for nerve exit and triangular sacral canal
Coccygeal	Fused as small triangular bone—the coccyx

JOINTS

- Intervertebral (IV) discs
  - Connect articulating surfaces of adjacent vertebral bodies
  - Integral part of secondary cartilaginous joints between vertebral bodies *(except C1/2)*
  - Composed of tough annulus fibrosus surrounding an avascular, gelatinous nucleus pulposus
  - Act as "shock absorbers" and semifluid ball bearings to provide small movements between individual vertebrae
- Zygapophysial (or facet) joints
  - Synovial joints between superior and inferior articular processes
  - Surrounded by thin, loose articular capsule
  - Permit gliding movements between vertebrae
- Atlanto-occipital joints
  - Synovial joints between lateral masses of atlas and occipital condyles
  - Permit flexion/extension and *some* lateral bending and rotation
- Atlanto-axial joints
  - Three synovial joints between inferior lateral masses of C1 and superior facets of C2 and between anterior arch of C1 and dens of C2
  - Permit rotation of C1 (and head), which is limited by alar ligaments
- Costovertebral joints: synovial, between vertebrae and ribs *(see Section 3, Thorax)*
- Sacro-iliac (SI) joints: synovial joints *(see Section 5, Pelvis and Perineum)*

Ligament	Features
Anterior longitudinal	Limits extension Maintains stability of IV discs
Posterior longitudinal	Limits flexion Prevents IV disc herniation
Intertransverse	Limits lateral bending
Interspinous	Limits flexion
Supraspinous	Limits flexion
Ligamenta flava	Limits flexion Preserves curvature of column Prevents injury to IV discs
Ligamentum nuchae	Prevents cervical hyperflexion Attachment site for trapezius and rhomboid minor

CLINICAL POINTS

TYPES OF VERTEBRAL FRACTURES

- Compression fracture
  - Vertebral body collapses
  - Caused by osteoporosis, trauma, or tumor
  - Usually occur at C7 and T1
  - Moderate to severe pain, limitation of movement, kyphosis
- Jefferson fracture
  - Four part fracture of ring of C1
  - Caused by a fall on vertex
  - Patients have upper neck pain but can be neurologically intact.
- Hangman fracture
  - Caused by hyperextension of head on neck
  - Bipedicle fracture of C2
  - Anterior displacement of C2 and C3
  - Results in quadriplegia or death

CERVICAL HYPEREXTENSION

- Most common in young adults (trauma and sports injuries) and elderly, resulting in cord compression
- Result of whiplash from car accidents
- Results in soft tissue injury, fractures, dislocations, ligamentous tears, and disc disruption

SPINAL CURVATURES

The primary curvatures of the vertebral column in the thoracic and sacral regions develop during the fetal period and are caused by differences in height between the anterior and posterior aspects of the vertebrae. The secondary curvatures are mainly a result of anterior-posterior differences in IV disc thickness. The cervical curvature is acquired when an infant begins to lift his head, and the lumbar curvature when an infant begins to walk.

Abnormal Curvatures

Kyphosis. Kyphosis is an increased thoracic curvature, commonly seen in the elderly *("Dowager hump")*. It is usually caused by osteoporosis, resulting in anterior vertebral erosion or a compression fracture. An excessive lumbar curvature is termed a **lordosis** and is seen in association with weak trunk muscles, pregnancy, and obesity. **Scoliosis** is an abnormal lateral curvature of the spine, accompanied by rotation of the vertebrae.

Spondylolisthesis. The lumbosacral angle is created between the long axes of the lumbar vertebrae and the sacrum. It is primarily because of the anterior thickness of the L5 body. As the line of body weight passes *anterior* to the SI joints, anterior displacement of L5 over S1 may occur (spondylolisthesis), applying pressure to the spinal nerves of the cauda equina.

Sacralization. In about 5% of individuals, the L5 vertebra is partially or totally fused with the sacrum. Because the L5/S1 level is now very strong, the L4/5 level is likely to degenerate in these cases.

MEMORY AIDS

Vertebral bodies

Thoracic are **heart**-shaped since your **heart** is in your thorax

Lumbar are **kidney-bean** shaped as the **kidneys** are in the lumbar area

Craniovertebral joints

Atlanto-occipital joint is the **yes-yes joint** because it permits nodding

2.3 SPINAL CORD

Study Aims

At the end of your study, you should be able to:

- Draw a schematic transverse section through the spinal cord, meninges, and vertebrae
- Understand the structure and function of the dorsal and ventral spinal nerve roots and rami
- Understand the general topography and synaptic transmitters of the autonomic nervous system
- Know the levels of the principle dermatomes
- Describe the vasculature supply of the spinal cord and vertebral column

GUIDE

SPINAL CORD—OVERVIEW

- Originates at inferior end of medulla oblongata and terminates as conus medullaris
- Approximately 42 to 45 cm long from foramen magnum to L2 *(variable from T12–L3)*
- Connected from conus medullaris to coccyx by filum terminale (a strand of connective tissue that connects exits from dural sac and passes through sacral hiatus)
- Two regional enlargements
  - Cervical—origin of brachial plexus innervating upper limb
  - Lumbosacral—origin of lumbar and sacral plexuses innervating lower limb
- Has the following features in cross section
  - Dorsal median sulcus and ventral median fissure that divide cord into symmetrical halves
  - Central canal carrying cerebrospinal fluid (CSF)
  - White matter surrounding an H-shaped core of gray matter (ventral and dorsal horns)

Structure of Spinal Nerves

- 31 pairs of spinal nerves
  - 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 1 coccygeal
  - C1–C7 exit superior to corresponding vertebrae
  - C8 exits inferior to C7 vertebra
  - T1–Co exit inferior to corresponding vertebrae
- Cauda equina: spinal nerve roots inferior to conus medullaris, travelling obliquely to exit vertebral canal
- Ventral roots
  - Carry efferent (motor) fibers with their cell bodies in ventral horn of cord
  - May contain presynaptic autonomic fibers
- Dorsal roots
  - Carry afferent (general and visceral sensory) fibers with their cell bodies in dorsal root ganglion (DRG)
  - May be absent in C1 and Co
- Ventral and dorsal roots combine to form a (mixed) spinal nerve that exits through intervertebral foramen and divides almost immediately into (mixed) ventral and dorsal rami
- Ventral rami
  - Anterior and lateral branches
  - Form plexuses and supply limbs and trunk
- Dorsal rami
  - Medial and lateral branches
  - Supply skin and true muscles of back

Meninges

- Dura mater: tough fibroelastic membrane
  - Continuous with inner (meningeal) layer of cranial dura
  - Attached to margins of foramen magnum and posterior longitudinal ligament
  - Separated by epidural space from vertebral periosteum
  - Extends as a sac from margin of foremen magnum to level of S2
  - Pierced by spinal nerves
  - Anchored to coccyx by external filum terminale
  - Forms dural root sleeves covering spinal nerves before fusing with epineurium
- Arachnoid mater: delicate, avascular, fibroelastic membrane lining dural sac
  - Opposed *(held to inner surface)* to dura by CSF pressure
  - Is external to subarachnoid space, between arachnoid and pia, containing CSF, traversed by strands of connective tissue (arachnoid trabeculae)
  - Contains lumbar cistern, an enlargement of subarachnoid space between L2 *(end of spinal cord)* and S2 *(end of dural sac)*
- Pia mater: highly vascular innermost layer covering roots of spinal nerves
  - Continues as filum terminale
  - Suspends spinal cord within dural sac by lateral extensions between anterior and posterior roots, called denticulate ligaments

Dermatomes

- A well-defined strip of skin extending from anterior to posterior midline, supplied by a single spinal nerve
  - Cervical supply neck and upper limb
  - Thoracic supply trunk *(T1 also supplies upper limb)*
  - C5 abuts T1 on superior anterior chest wall
  - Lumbar predominantly supply anterior lower limb
  - Sacral predominantly supply posterior lower limb

Dermatome Levels To Know

Level	Somatic Supply
C5	Clavicles
T4	Nipples
T10	Level of umbilicus
L1	Inguinal ligament
L3/4	Over knee
S2–S4	Perineum

Vasculature of Spinal Cord and Vertebral Column

- Anterior spinal artery
  - Single artery running in ventromedian fissure
  - Arising from branches of vertebral arteries *(with contributions from ascending cervical, deep cervical, intercostal, lumbar, and sacral arteries)*
  - Supplies anterior two thirds of spinal cord and vertebral bodies
- Posterior spinal arteries
  - Paired longitudinal arteries arising from vertebral or posterior inferior cerebellar arteries
  - Supply posterior one third of spinal cord and vertebral bodies
- Radicular arteries
  - Dorsal and ventral arteries arising from ascending cervical, deep cervical, intercostal, lumbar, and sacral arteries
  - Supply nerve roots *(called* segmental arteries *if they reach anterior or posterior spinal arteries)*
- Great anterior segmental artery (of Adamkiewicz)
  - Occurs on left side in 65% of individuals
  - Contributes to two thirds of circulation to inferior spinal cord
- Veins: usually 3 anterior and 3 posterior longitudinal spinal veins with tributaries from posterior medullary and radicular veins. They drain into valveless vertebral venous plexus.
- Vertebral venous plexus is continuous with cranial dural venous sinuses and contains no valves
  - Internal vertebral plexus (lying in extradural space) drains spinal cord.
  - External vertebral plexus connects with azygos vein and superior and inferior vena cavae.

Autonomic Nervous System (ANS)

- Sympathetic NS: catabolic system for fight or flight
  - T1–L2/3 (thoracolumbar) levels
  - Presynaptic (preganglionic) neurons have cell bodies located in intermediolateral cell columns of spinal cord *(T1–L2 only)* and utilize acetylcholine (Ach) as their neurotransmitter and synapse in para- or prevertebral ganglia.
  - Postsynaptic (postganglionic) neurons have cell bodies in paravertebral and prevertebral ganglia.
  - Paravertebral ganglia are linked to form right and left sympathetic chains *(superior, middle, and inferior cervical ganglia, T1–S5)*.
  - Paravertebral ganglia are attached to spinal nerves by white (T1–L2) and gray (C1–Co) rami communicantes.
  - Long postsynaptic neurons utilize norepinephrine as their neurotransmitter.
  - Prevertebral ganglia *(celiac, superior, and inferior mesenteric, aorticorenal)* are in plexuses surrounding origins of main branches of abdominal aorta.
  - Splanchnic nerves are presynaptic fibers that pass through paravertebral ganglia without synapsing to enter cardiac, pulmonary, esophageal, various abdominal and pelvic plexuses, where they synapse.
  - Sympathetic fibers innervate smooth muscle, modified cardiac muscle, glands, and medulla of suprarenal glands.
- Parasympathetic NS: anabolic system for homeostasis
  - S2–S4 levels and cranial nerves III, VII, IX, X (craniosacral)
  - Long presynaptic neurons (Ach) with cell bodies in mediolateral gray matter (S2–S4)
  - Short postsynaptic neurons arising near target organs (Ach)
  - Innervation of smooth muscle, modified cardiac muscle, and glands of thoracic, abdominal, and pelvic viscera
- Visceral afferent NS: provides sensory input from body's internal environment
  - Provides visceral sensation
  - Can trigger both somatic and visceral reflexes

CLINICAL POINTS

DISC HERNIATION

Protrusion of the nucleus pulposus through the annulus fibrosus

- 95% at the L4/5 or L5/S1 level
- Usually posterolateral herniation where annulus is thinnest
- Herniation into the vertebral canal may compress the nerve root below the disc and cause pain in the related dermatome.
- Age-related dehydration of nucleus pulposus contributes to loss of height and narrowing of IV foramina.

LUMBAR SPINAL STENOSIS

- Narrowing of the vertebral canal
- Compression of spinal cord caused by age-related degenerative changes such as bulging of the IV discs or arthritis
- Surgical laminectomy or removal of the entire vertebral arch may be necessary to alleviate symptoms.

SPINAL CORD DEVELOPMENT

In the fetus, the spinal cord extends down to the sacral vertebrae. As a fetus matures, the cord shortens relative to the rest of the body, so at birth the conus medullaris reaches the L2/3 level, and by adulthood only around the level of the L1/2 IV disc, where the cauda equina begins.

EPIDURAL BLOCK

An epidural block is anesthetic injected into epidural space of the sacral canal either via the sacral hiatus *(caudal epidural)* using the sacral cornua as landmarks, or via the posterior sacral foramina *(transsacral epidural)*. The anesthetic solution spreads superiorly to act on spinal nerves S2–Co. The height to which the anesthetic ascends is affected by the amount of solution injected and the position of the patient.

SPINAL BLOCK

A spinal block is the introduction of an anesthetic directly into the CSF (in the subarachnoid space) utilizing a lumbar puncture *(see above)*. Onset of anesthesia is rapid <1 minute *(unlike epidural anesthesia, which may take up to 20 minutes)*. Subsequent leakage of CSF may cause a headache in some individuals.

MEMORY AIDS

Dermatomes

T-ten over your belly but-ten
L3 over the knee
Sit on Sacral dermatomes

2.4 MUSCLES AND NERVES

Study Aims

At the end of your study, you should be able to:

- Describe the origins, insertions, major functions, and innervation of the superficial, intermediate, and deep muscles of the back
- Identify structures of the back as seen in transverse section
- Understand the anatomy of the suboccipital triangle
- Describe the typical organization of the thoracic spinal nerves

GUIDE

The muscles of the back are divided into the extrinsic muscles that connect the upper limb to the trunk and the intrinsic (deep or true) muscles that specifically act on the vertebral column to produce movements and maintain posture.

EXTRINSIC MUSCLES OF THE BACK

- Superficial: trapezius, latissimus dorsi, levator scapulae, rhomboid minor and major
- Intermediate: serratus posterior superior and posterior inferior *(muscles of respiration)*

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Trapezius	Superior nuchal line, external occipital protuberance, nuchal ligament, and spinous processes of C7–T12	Lateral third of clavicle, acromion, spine of scapula	Accessory nerve (cranial nerve XI) and C3–C4 (proprioception)	Elevates, retracts, and rotates scapula; lower fibers depress scapula	Transverse cervical artery, dorsal perforating branches of posterior intercostal arteries
Latissimus dorsi	Spinous processes of T7–L5, thoracolumbar fascia, iliac crest, and last three ribs	Humerus (intertubercular sulcus)	Thoracodorsal nerve (C6–C8)	Extends, adducts, and medially rotates humerus at shoulder	Thoracodorsal artery, dorsal perforating branches of 9th, 10th, and 11th posterior intercostal, subcostal, and first three lumbar arteries
Levator scapulae	Posterior tubercles of transverse processes of C1–C4	Medial border of scapula from superior angle to spine	Ventral rami of C3–C4 and dorsal scapular nerve	Elevates scapula medially, inferiorly rotates glenoid cavity	Dorsal scapular artery, transverse cervical artery, ascending cervical artery
Rhomboid minor	Ligamentum nuchae, spines of C7 and T1 vertebrae	Medial border of scapula at spine of scapula	Dorsal scapular nerve (C4–C5)	Fixes scapula to thoracic wall and retracts and rotates it to depress glenoid cavity	Dorsal scapular artery OR deep branch of transverse cervical artery, dorsal perforating branches of upper five or six posterior intercostal arteries

Continued

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Rhomboid major	Spinous processes of T2–T5 vertebrae	Medial border of scapula below base of spine of scapula	Dorsal scapular nerve (C4–C5)	Fixes scapula to thoracic wall and retracts and rotates it to depress glenoid cavity	Dorsal scapular artery OR deep branch of transverse cervical artery, dorsal perforating branches of upper five or six posterior intercostal arteries
Serratus posterior superior	Ligamentum nuchae, spinous processes of C7–T3	Superior aspect of ribs 2–4	Ventral rami of upper thoracic nerves	Elevate ribs	Posterior intercostal arteries
Serratus posterior inferior	Spinous processes of T11-L2	Inferior aspect of ribs 9–12	Ventral rami of lower thoracic nerves	Depress ribs	Posterior intercostal arteries

INTRINSIC MUSCLES OF THE BACK

- Superficial: splenius (capitus/cervicis)
- Intermediate: erector spinae (sacrospinalis) group—iliocostalis (lumborum/thoracis/cervicis) longissimus (thoracis/cervicis/capitis), spinalis (thoracis/cervicis/capitis)
- Deep: transversospinal group—semispinalis (thoracis/cervicis/capitis), multifidus, rotatores
- Minor deep: interspinales, intertransversarii, levatores costarum (brevis and longus)

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Superficial Layer					
Splenius capitis	Nuchal ligament, spinous process of C7–T3	Mastoid process of temporal bone and lateral third of superior nuchal line	Dorsal rami of middle	*Bilateral:* extend head *Unilateral:* laterally bends (flexes) and rotates face to same side	Descending branch of occipital artery, deep cervical artery
Splenius cervicis	Spinous process of T3–T6	Transverse process (C1–C3)	Dorsal rami of lower cervical nerves	*Bilateral:* extend neck *Unilateral:* laterally bend (flex) and rotate neck toward same side	Descending branch of occipital artery, deep cervical artery
Intermediate Layer					
Erector spinae	Posterior sacrum, iliac crest, sacrospinous ligament, supraspinous ligament, spinous processes of lower lumbar and sacral vertebrae	*Iliocostalis*: angles of lower ribs and cervical transverse processes *Longissimus*: between tubercles and angles of ribs, transverse processes of thoracic and cervical vertebrae, and mastoid process *Spinalis*: spinous processes of upper thoracic and midcervical vertebrae	Dorsal rami of each region	Extends and laterally bends vertebral column and head	*Cervical portions*: occipital, deep cervical, and vertebral arteries *Thoracic portions*: dorsal branches of posterior intercostal, subcostal, and lumbar arteries *Sacral portions:* dorsal branches of lateral sacral arteries

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Deep Layer					
Semispinalis	Transverse processes of C4-T12	Spinous processes of cervical and thoracic regions	Dorsal rami of spinal Nerves	Extend head, neck, and thorax and rotate them to opposite side	*Cervical portions:* occipital, deep cervical, and vertebral arteries *Thoracic portions:* dorsal branches of posterior intercostal arteries
Multifidi	Sacrum, ilium, transverse processes of T1–T12, and articular processes of C4–C7	Spinous processes of vertebrae above, spanning two to four segments	Dorsal rami of each region	Stabilizes spine	*Cervical portions:* occipital, deep cervical, and vertebral arteries *Thoracic portions*: dorsal branches of posterior intercostal, subcostal, and lumbar arteries *Sacral portions:* dorsal branches of lateral sacral arteries
Rotatores	Transverse processes of cervical, thoracic, and lumbar regions	Lamina and transverse process of spine above, spanning one or two segments	Dorsal rami of spinal nerves	Stabilizes, extends, and rotates spine	Dorsal branches of segmental arteries

FASCIA

- Encloses deep muscles of back
- Attached medially to nuchal ligament, tips of spinous processes, supraspinous ligament, and median line of sacrum
- Attached laterally to cervical and lumbar transverse processes
- Thickened as thoracolumbar fascia toward lumbar region and extends between twelfth rib and iliac crest

VASCULAR SUPPLY TO MUSCLES AND SKIN OF THE BACK

- Arteries
  - Cervical: branches from occipital, ascending cervical, vertebral, and deep cervical
  - Thoracoabdominal: branches of posterior intercostals, subcostal, and lumbar
  - Pelvic: iliolumbar and lateral sacral branches of internal iliac
- Veins drain via valveless vertebral venous plexus
- Lymph
  - Neck: drains to anterior, lateral, and deep cervical nodes
  - Trunk: drains to axillary nodes above umbilicus and superior inguinal nodes below it

SUBOCCIPITAL REGION

- Inferior to occiput, deep to trapezius and semispinalis capitis, overlying C1 and C2
- Muscles
  - Rectus capitis posterior minor and major
  - Obliquus capitis superior and inferior
  - *All laterally flex, extend, and rotate head.*
  - *All are supplied by suboccipital nerve (dorsal ramus of C1).*
- Contains dorsal rami of C1–C4
- Suboccipital triangle
  - Contains vertebral artery, suboccipital nerve and suboccipital venous plexus
  - Bounded by rectus capitis posterior major, obliquus capitis superior and obliquus capitis inferior; floor—atlanto-occipital membrane; roof—semispinalis capitis

Deep Layer

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Rectus capitis posterior major	Spine of axis	Lateral inferior nuchal line	Suboccipital nerve (C1)	Extends and rotates head to same side	Vertebral artery, descending branch of occipital artery
Rectus capitis posterior minor	Tubercle of posterior arch of atlas	Median inferior nuchal line	Suboccipital nerve (C1)	Extends head	Vertebral artery, descending branch of occipital artery
Obliquus capitis superior	Transverse process of atlas	Occipital bone	Suboccipital nerve (C1)	Extends and bends head laterally	Vertebral artery, descending branch of occipital artery
Obliquus capitis inferior	Spine of axis	Transverse process of atlas	Suboccipital nerve (C1)	Rotates atlas to turn face to same side	Vertebral artery, descending branch of occipital artery

BRANCHES OF SPINAL NERVES

- Ventral rami innervate muscles and overlying skin of anterior thoracic, abdominal, and pelvic wall and contribute to
  - Cervical plexus [C1–C4] *(see Section 1, Head and Neck)*
  - Brachial plexus [C5–T1] *(see Section 6, Upper Limb)*
  - Thoracic intercostal nerves *(see Section 3, Thorax)*
  - Lumbar plexus [T12–L4] *(see Sections 5 and 7, Pelvis and Perineum, and Lower Limb)*
  - Sacral plexus [L4–S5] *(see Section 7, Lower Limb)*
- Dorsal rami
  - C1: Suboccipital nerve—pierces atlanto-occipital membrane and is motor to suboccipital muscles
  - C2: Greater occipital nerve—passes inferior to OCI and is sensory to skin over neck and occipital bone
  - C3–Co: Segmentally innervate intrinsic muscles of back and overlying skin

CLINICAL POINTS

BACK PAIN

Back pain is a very common, usually self-limiting complaint, often affecting the lumbar region *("low back pain")*. Radiation to back of the thigh and into the leg *(sciatica)* or focal neurology suggests radiculopathy. Disturbance of bladder/bowel function should prompt urgent intervention.

BACK STRAIN

Back strain is a stretching and microscopic tearing of muscle fibers or ligaments, often because of a sport-related injury. The muscles subsequently go into spasm as a protective response, causing pain and interfering with function. This is a common cause of low back pain.

WHIPLASH

Whiplash is cervical muscle and/or ligament strain because of forceful hyperextension of the neck. Frequently caused by impacts from the rear in motor vehicle accidents. May cause herniation of the IV disc and subsequent radiculopathy.

MEMORY AIDS

Deep back muscles: **I** **L**ove **S**paghetti—**S**ome **M**ore **R**agu
Iliocostalis, **L**ongissimus, **S**pinalis—**S**emispinalis, **M**ultifidus, **R**otatores

Erector spinae group: **I** **L**ike **S**tanding
Iliocostalis, **L**ongissimus, **S**pinalis

Thorax Study Guide 3

3.1 TOPOGRAPHIC ANATOMY

Study Aims

At the end of your study, you should be able to:

- Identify the major features of the surface anatomy of the chest wall
- Identify the location of the sternoclavicular and manubriosternal joints
- Know the types of these joints
- Palpate the sternum and its parts

GUIDE

- The thorax lies between the neck and the abdomen and lies within a cage formed by the vertebrae, the ribs, the sternum, the costal cartilages, and their attached muscles. The thoracic cage protects the contents of the thorax, whereas the muscles assist in breathing.
- It is important to identify and count ribs because they form key landmarks to the positions of the internal organs.
- In a fit, muscular person one can identify a number of landmarks
  - Jugular (suprasternal) notch: at level of inferior border of T2 vertebra
  - Sternal angle (manubriosternal join): at level of T4/5 intervertebral disc and where second costal cartilages articulate with sternum
  - Manubrium: left brachiocephalic vein runs beneath manubrium from upper left to lower right, where it joins right brachiocephalic vein to form superior vena cava.
  - Body of sternum: anterior to T5 through T9 vertebrae and right border of heart
  - Nipple: anterior to 4th intercostal space in males and dome of right hemidiaphragm; sits on pectoralis major muscle
  - Xiphoid process: at level of T10 vertebra
  - The costal margins: comprises 7th through 10th costal cartilages
- On yourself, palpate the following:
  - The sternoclavicular joints, lateral to jugular notch
  - The sternum and its parts: manubrium, body, and xiphoid process
  - The manubriosternal joint (sternal angle)
  - The second pair of ribs on either side of sternal angle—the surface landmark for rib counting
- Surface lines can be drawn to identify regions of the thorax.
  - Imaginary perpendicular lines passing through midpoint of each clavicle are called midclavicular lines.
  - Midaxillary lines are perpendicular lines through apex of axilla on both sides.
- Cephalic vein can be seen in some subjects; it lies in deltopectoral groove between deltoid and pectoralis major muscles.

CLINICAL POINTS

- The sternum can be divided to gain access to the thoracic cavity for surgical operations. This is called a median sternotomy.
- The middle ribs are most commonly fractured, and multiple rib fractures can manifest as a "flail chest," where the injured region of the chest wall moves paradoxically, that is, in on inspiration and out on expiration.

3.2 MAMMARY GLAND

Study Aims

At the end of your study, you should be able to:

- Identify the mammary gland
- Identify the location of the gland
- Locate the blood supply of the breast
- Understand the lymphatic drainage of the breast
- Know how to palpate the breast

GUIDE

- Consists of glandular tissue in which the majority is embedded within the tela subcutanea (superficial fascia) of the anterior chest wall overlying the pectoral muscles
- The glands are rudimentary in males and immature females.
- Size and shape of the adult female breast varies; size is determined by amount of fat surrounding glandular tissue.

- The base of the breast is fairly consistent, extending from lateral border of sternum to midaxillary line and from 2nd to 6th ribs.
- The majority of the breast overlies deep pectoral fascia of pectoralis major muscle, with remainder overlying fascia of serratus anterior.
- The breast is separated from pectoralis major muscle by retromammary space, a potential space filled with loose connective tissue.
- The breast is firmly attached to overlying skin by condensation of connective tissue called suspensory ligaments (of Cooper), which help to support lobules of the breast.
- A small part of the mammary gland may extend toward the axilla, called the axillary tail (of Spence).

STRUCTURE OF THE BREAST

- For descriptive purposes, the breast is divided into four quadrants: upper and lower lateral, and upper and lower medial.
- The most prominent feature of the breast is the nipple.
- The nipple is surrounded by the areola, a circular pigmented area of skin.
- The areola is pink in Caucasians and brown in African and Asian people.
- The pigmentation of the areola increases during pregnancy.
- The areola contains sebaceous glands; following a pregnancy these secrete an oily substance to protect the mother's nipple from irritation during nursing.
- The breast is composed of 15 to 20 lobules of glandular tissue, formed by septa of suspensory ligaments.
- The mammary glands are modified sweat glands that are formed from development of milk-secreting alveoli, arranged in clusters.
- Each lobule is drained by a lactiferous duct.
- Each lactiferous duct opens on the nipple.

VASCULATURE OF THE BREAST

- Blood supply of the breast arises from the perforating branches and anterior intercostal branches of the internal thoracic artery.
- The breast is also supplied by the branches of the thoracoacromial and lateral thoracic arteries (from the axillary artery).
- Venous drainage parallels the arterial supply and is mainly to the axillary artery and internal thoracic vein.

LYMPHATIC DRAINAGE OF THE BREAST

- Lymph from the nipple, areola, and lobules of the mammary glands drains to a subareolar lymphatic plexus.
- From there, a system of interconnecting lymphatic channels drains lymph to various lymph nodes.
- The majority of the lymph, especially from the lateral quadrants of the breast, drains to the pectoral nodes, and from there to the axillary nodes.
- The remaining amount of lymph, especially from the medial quadrants of the breast, drains into the parasternal lymph nodes along the internal thoracic vessels.
- Some lymph from the lower quadrants of the breast passes to the inferior phrenic nodes.
- Lymph from the medial quadrants can cross to the opposite breast.
- Secondary metastases of breast carcinoma can spread to the opposite breast in this way.

CLINICAL POINTS

EXAMINATION OF THE BREAST

Clinically the breast is divided into quadrants:

- UI: upper inner
- UO: upper outer (includes axillary tail)
- LI: lower inner
- LO: lower outer

The breast is palpated in a circular fashion, beginning with the nipple and moving outward. The palpation should extend into the axilla to palpate the axillary tails. After palpation of one breast, the other should be palpated in the same way. Examine the skin of the breast for a change in texture or dimpling (peau d'orange sign) and the nipple for retraction, since these signs may indicate underlying disease.

PATHOLOGY OF THE BREAST

- **Fibroadenoma:** benign tumor, usually a solid and solitary mass that moves easily under the skin. Often painless, although sometimes tender on palpation. More common in young women but can occur at any age.
- **Intraductal carcinoma, or breast cancer:** the commonest type of malignancy in women but can also occur in men. Approximately 50% of cancers develop in the upper quadrant of the breast; metastases from these cancers often spread to the axillary lymph nodes. This malignancy presents as a palpable mass that is hard, immobile, and sometimes painful. Additional signs can include bloody or watery nipple discharge if the larger ducts are involved.
- **Gynecomastia:** enlargement of the breasts in males because of aging, drug treatment, and changes in the metabolism of sex hormones by the liver.

3.3 BODY WALL

Study Aims

At the end of your study, you should be able to:

- Identify muscles of the anterior chest wall and know their attachments, actions, and innervation
- Identify the intercostal muscles
- Identify the ribs and their parts
- Count ribs
- Understand the organization of a typical intercostal space and clinical significance of its contents

GUIDE

LAYERS

- First and second
  - Skin
  - Tela subcutanea (superficial fascia), including the breasts

- Third—muscles moving upper limb
  - Pectoralis major
  - Pectoralis minor
  - Serratus anterior
- Fourth—includes muscles of chest wall
  - Ribs
- Intercostal muscles
  - External intercostal muscles
  - Internal intercostal muscles
  - Innermost intercostal muscles

INTERCOSTAL MUSCLES

These muscles are arranged in three layers

- External intercostal muscles
  - Have fibers that slope down and medially
  - Extend from posterior tubercle of rib to junction of rib and its costal cartilage anteriorly
  - Anteriorly, are replaced by external intercostal membranes that extend from costochondral junctions to sternum
- Internal intercostal muscles:
  - Lie internal to external intercostal muscles
  - Their fibers lie at right angles to those of external intercostal muscles and run inferiorly and laterally.
  - Anteriorly extend to lateral border of sternum
  - Posteriorly extend only to angles of ribs; medial to angles, are replaced by internal intercostal membranes
- Innermost intercostal muscles
  - Lie deep to internal intercostal muscles
  - Separated from internal intercostals by intercostal vessels and nerves
  - Occupy middle parts of intercostal spaces
- Connect inner surfaces of adjacent ribs
- All intercostal muscles are supplied by intercostal nerves corresponding in number to their intercostal space.
- Main action of intercostals is to maintain space between ribs during inspiration and expiration.
- Other muscles of rib cage
  - Subcostal muscles—internal to internal intercostals, cross from angle of one rib to internal surface of rib 1 to 2 spaces below
  - Transversus thoracis—4 to 5 slips of muscle that attach to xiphoid process and inferior sternum and pass superiorly and laterally to attach to 2nd through 6th costal cartilages

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
External intercostal	Lower border of ribs	Upper border of rib below rib of origin	Intercostal nerves	Supports intercostal spaces in inspiration and expiration, elevates ribs in inspiration	Posterior intercostal arteries, collateral branches of posterior intercostal arteries, costocervical trunk, anterior intercostal branches of internal thoracic artery, musculophrenic artery
Internal intercostal	Lower border of ribs	Costal cartilage and edge of costal groove of rib above rib of origin	Intercostal nerves	Prevents pushing out or drawing in of intercostal spaces in inspiration and expiration, lowers ribs in forced expiration	Muscular branches of anterior intercostal arteries, muscular branches of posterior intercostal arteries, intercostal branches of internal thoracic and musculophrenic arteries, costocervical trunk branches
Innermost intercostal	Lower border of ribs	Upper border of rib below rib of origin	Intercostal nerves	Act similar to internal intercostals	Muscular branches of anterior intercostal arteries, muscular branches of posterior intercostal arteries, intercostal branches of internal thoracic and musculophrenic arteries, costocervical trunk branches
Transversus thoracis	Internal surface of costal cartilages 2–6	Posterior surface of lower sternum	Intercostal nerves	Depress ribs and costal cartilages	Anterior intercostal arteries, internal thoracic artery
Subcostal	Internal surface of lower rib near their angles	Superior borders of 2nd or 3rd rib below	Intercostal nerves	Depress ribs	Posterior artery, musculophrenic artery
Levator costarum	Transverse processes of C7 and T1–T11	Subjacent ribs between tubercle and angle	Dorsal ramus of lower thoracic nerves	Elevate ribs	Posterior intercostal arteries

INTERCOSTAL NERVES

- Intercostal nerves arise from the ventral rami of the upper eleven thoracic spinal nerves.
- Each intercostal nerve divides to give a lateral cutaneous branch near the midaxillary line.
- Anterior cutaneous branches innervate skin on anterior abdomen and thorax and divide into medial and lateral branches.
- Muscular branches supply intercostal, levatores costarum, transversus thoracis, and serratus posterior muscles.
- The lower five intercostal nerves supply skin and muscles of abdominal wall.
- Contain general somatic afferent and efferent fibers, as well as general visceral efferent fibers from sympathetic trunk via white and gray rami communicantes and general visceral afferent fibers.

RIBS

- All ribs contain bone marrow.
- Ribs 1 through 7 are vertebrocostal because they attach to sternum via a costal cartilage.
- Ribs 8 through 10 are vertebrochondral because their cartilages are joined to cartilage of rib above and via that connection to sternum.
- Ribs 11 and 12 are free or floating ribs that do not connect even indirectly with sternum but that have a costal cartilage on their tips.
- First rib is broad and sharply curved and has a tubercle of attachment of scalene muscles.

ANATOMICAL AND CLINICAL POINTS

IMPORTANT VERTEBRAL LANDMARKS

- Spine of scapula: T2
- Sternal angle (of Louis); level of bifurcation of trachea, arch of aorta: T4/T5
- Level of the heart: T5–T8
- Aortic hiatus of diaphragm; also transmits thoracic duct: T12
- Esophageal hiatus of diaphragm; also transmits right and left vagal trunks, esophageal branches of left gastric vessels, and lymphatics: T10
- Caval opening of diaphragm; also terminal branches of right phrenic nerve: T8

THORACOCENTESIS

Thoracocentesis is the insertion of a needle into the pleural cavity to withdraw a sample of fluid or blood. To avoid damage to the intercostal vein, artery, and nerve that run in the costal groove on the inferior surface of each rib, the needle is inserted superior to the rib.

IMPORTANCE OF CERTAIN INTERCOSTAL SPACES

- Second intercostal space at the midclavicular line: insertion of tube for an apical pneumothorax (thoracostomy)
- 4th to 6th intercostal space at the midaxillary line: insertion of chest drains for a hemothorax (thoracostomy)
- Left 5th intercostal space: apex beat of the heart and this is shifted in heart enlargement

CERVICAL RIBS

Cervical ribs are not common (less than 1% of all persons). They articulate with the C7 vertebra but do not attach to the sternum. They may fuse with the first rib. If a cervical rib is present, however, it may compress the subclavian artery or inferior trunk of the brachial plexus and cause ischemic pain and numbness in the shoulder and upper limb. This condition is called thoracic outlet syndrome.

BONE MARROW BIOPSY AND ASPIRATION

Bone marrow aspiration and biopsy help diagnose many blood disorders and can be used to detect if cancer has spread to the bone marrow.

- **Bone marrow biopsy:** The removal of bone and marrow for examination under the microscope. The sternum is a site of red marrow, even in adulthood, and is a good site for a bone marrow biopsy. Another common site is the posterior iliac crest. A biopsy is usually conducted before performing a bone marrow aspiration.
- **Bone marrow aspiration:** The removal of a small amount of bone marrow fluid through a needle inserted into the bone. Fluid is examined to determine if there are any problems with the blood cells made in the bone marrow

MEMORY AIDS

Vertical order of the contents of the neurovascular bundle in the costal groove on the lower border of each rib:
VAN: Vein, **A**rtery, **N**erve

3.4 LUNGS

Study Aims

At the end of your study, you should be able to:

- Understand the relationship of the pleural cavities to the mediastinum
- Identify the pleurae and the parts of the parietal pleura
- Understand the anatomy of the lungs
- Know the segments of the lungs
- Understand vasculature and innervation of the lungs and the pleurae

GUIDES

THORACIC CAVITY, PLEURAE, AND PLEURAL CAVITY

- Thoracic cavity
  - Two lateral pleural cavities containing the lungs and pleurae
  - Central compartment, the mediastinum, containing all other thoracic structures
- Each lung is surrounded by, and covered with, a continuous membrane, which is defined as
  - Visceral pleura, which covers the lungs and cannot be dissected from the lung
  - Parietal pleura, which lines pleural cavities

- The visceral and parietal pleura are continuous at hilum of the lung where structures enter and leave the lung (bronchus, pulmonary vessels, bronchial vessels, lymphatics).
- The parietal pleura has four named parts.
  - Costal pleura lining internal surface of thoracic wall
  - Mediastinal pleura covering sides of mediastinum
  - Diaphragmatic pleura covering superior surface of dome of each hemidiaphragm
  - Cervical pleura, dome of pleura extending superiorly into superior thoracic aperture
- Visceral pleura does not have any general sensory innervation and is insensitive to pain.
- The parietal pleura is very sensitive to pain because of its sensory supply by branches of intercostal and phrenic nerves.
- The pleural cavity is potential space between parietal and visceral pleura.
  - Pleural cavity contains a thin layer of serous pleural fluid, which lubricates and allows pleurae to move smoothly over each other during respiration.
  - Surface tension keeps lung surface in contact with thoracic wall.
  - The lung expands and fills with air when thoracic cavity expands.

Lines of Pleural Reflection

- Lines of pleural reflection are lines along which parietal pleura changes directions from one wall to another.
  - Sternal line of pleural reflection is sharp line along which costal pleura becomes mediastinal pleura.
  - Costal line of pleural reflection is sharp line along which costal pleura becomes diaphragmatic pleura.
  - Vertebral line of pleural reflection is a smooth reflection of costal pleura onto vertebrae posteriorly.
- The lines of pleural reflection on the left side can be remembered as *4-6-8-10-12*.
  - The line of pleural reflection on left descends in midline of sternum to 4th costal cartilage, where it deviates to left margin of sternum at 6th costal cartilage to accommodate pericardium and heart (cardiac notch).
  - This line then deviates to cross 8th rib at midclavicular line.
  - It crosses 10th rib at midaxillary line.
  - It then crosses 12th rib at approximately the neck.
- On the right side, line of pleural reflection descends at midline of sternum to xiphoid process, and then deviates 8-10-12.
- The lungs do not fully occupy pleural cavities during expiration.
- There are peripheral areas where diaphragmatic and costal pleura come in contact, referred to as the *costodiaphragmatic recesses*.
- There are areas posterior to sternum where costal and mediastinal pleura come in contact with each other, and these are called *costomediastinal recesses*.
- The costomediastinal recess is larger on the left because of the cardiac notch.
- During expiration, the lower limit of the lungs is two costal spaces above line of pleural reflection.
  - 6-8-10: 6th rib at the midclavicular line, 8th rib at the midaxillary line, and 10th rib at the neck
  - Thus the costodiaphragmatic recess is approximately two costal spaces deep.

LUNGS

- Organs of respiration
- Light, soft, and elastic
- The right lung is larger than the left and has three lobes.
  - Superior, or upper
  - Middle
  - Inferior, or lower
- The left lung has two lobes.
  - Superior, or upper
  - Inferior, or lower
- Fissures divide the lungs into lobes.
  - Each lung has an oblique fissure, separating upper lobe from lower lobe on the left and upper and middle lobes from lower lobe on the right.
    - Oblique fissure runs from 2nd thoracic vertebra posteriorly to 6th costal cartilage anteriorly, or along medial border of scapula when arm is raised above head.
  - The right lung has a horizontal fissure, separating middle lobe from upper lobe on the right.
    - Horizontal fissure runs from oblique fissure at midaxillary line along 4th rib to its costal cartilage anteriorly.
- The anterior margin of the left lung has an indentation—the cardiac notch, which often creates a thin process in the upper lobe called the lingula.
- Each lung has three surfaces.
  - Costal
  - Mediastinal
  - Diaphragmatic
- Each lung is connected to the mediastinum by the root of the lung
- Lung root contains
  - Main stem or lobar bronchi
  - Pulmonary vessels and bronchi
  - Bronchial vessels, lymphatics, and autonomic nerves
- The lung root is surrounded by a pleural sleeve, from which extends pulmonary ligament inferiorly.
- The pulmonary ligament

Bronchopulmonary Segments

- The trachea bifurcates into two main stem bronchi, right and left, at level of T4/5 intervertebral disc (also the sternal angle of Louis).
- The carina is keel-like ridge between two openings of main stem bronchi.
- The right main stem bronchus divides into upper and lower lobar bronchi before reaching substance of the right lung.
- The main bronchi branch to form the bronchial tree.
- There are three lobar bronchi on the right: upper, middle, and lower.
- There are two lobar bronchi on the left: upper and lower.
- Each lobar bronchus branches into segmental bronchi that supply a bronchopulmonary segment.

- A bronchopulmonary segment
  - Is a pyramid-shaped section of the lung with its base covered by visceral pleura
  - Is separated from adjacent segments by connective tissue septa
  - Is named for segmental bronchus that supplies it
  - Has its own bronchus and segmental branch of pulmonary artery
- Each bronchopulmonary segment can be surgically resected, independent of adjacent segments.
- The right lung has 10 bronchopulmonary segments
  - Upper lobe: apical
    - Anterior
    - Posterior
  - Middle lobe: medial
    - Lateral
  - Lower lobe: superior
    - Anterior basal
    - Posterior basal
    - Medial basal
    - Lateral basal
- The left lobe has 8 to 10 bronchopulmonary segments.
  - Upper lobe: apical (may be combined with posterior to form apicoposterior)
    - Posterior
    - Anterior
    - Superior lingular
    - Inferior lingular
  - Lower lobe: superior
    - Anterior basal (may be combined with medial to form anteromedial basal)
    - Medial basal
    - Lateral basal
    - Posterior basal
- The right main stem bronchus is wider and shorter than the left one and descends in a more vertical plane, so aspirated foreign objects are more likely to lodge in it or one of its branches.
- Because the posterior segmental bronchus of the right lower lobe runs directly posterior, foreign objects that are inhaled when the person is lying down, such as food, may end up in this segmental bronchus.

Vasculature of the Lungs

- Each lung is supplied by a pulmonary artery, which carries unoxygenated blood from pulmonary trunk from right ventricle of the heart.
- Each pulmonary artery gives rise to lobar and segmental arteries.
- Intrasegmental veins drain to intersegmental veins in the pulmonary septa, which run a separate course from pulmonary and segmental arteries and which drain to two pulmonary veins for each lung.
- Pulmonary veins carry oxygenated blood to left atrium of the heart.
- Bronchial arteries from thoracic aorta carry oxygenated blood to tissue of the lungs, traveling along posterior surface of the bronchi.
- The left bronchial arteries come from the thoracic aorta; the single right bronchial artery may also arise from the superior posterior intercostal or a left superior bronchial artery.
- The bronchial arteries anastomose with branches of the pulmonary arteries.
- Pulmonary veins drain the blood to the lungs supplied by the bronchial veins and empty into the azygos and accessory hemi-azygos veins.
- The lungs have a rich, freely connecting network of lymphatic vessels.
- Lymph from the lungs drains to
  - Pulmonary lymph nodes (along the lobar bronchi)
  - Bronchopulmonary lymph nodes (along the main stem bronchi)
  - Superior and inferior tracheobronchial lymph nodes (superior and inferior to the bifurcation of the trachea)

Innervation of the Lungs

- Innervation is via the pulmonary plexuses located anterior and posterior to the lung roots.
- The plexuses contain postganglionic sympathetic fibers from the sympathetic trunks that innervate the smooth muscle of the bronchial tree, pulmonary vessels, and glands of the bronchial tree.
- Sympathetic fibers are bronchodilators, vasoconstrictors, and inhibit glandular secretion.
- The plexuses contain preganglionic parasympathetic fibers from the vagus nerve (CN X), small parasympathetic ganglia, and postganglionic parasympathetic nerves that innervate the smooth muscle of the bronchial tree, pulmonary vessels, and glands of the bronchial tree.
- Parasympathetic fibers are bronchoconstrictors, vasodilators, and secretomotor to the glands.
- Visceral afferent fibers carry information involved in cough reflexes, stretch reception, blood pressure, chemoreception, and nociception.

CLINICAL POINTS

- Diseases such as tuberculosis and sarcoidosis and lymphoma cause hilar lymphadenopathy that is visible on chest radiographs.
- Pneumonia: a bacterial or viral infection of the lung that can lead to widespread systemic infection and lung collapse. Pneumonia is frequently confined to a single lobe of one lung and is called lobar pneumonia. It can be clearly seen circumscribed to one lobe in a chest radiograph.
- The entry of air into a pleural cavity because of a penetrating wound or a fractured rib is called a pneumothorax and results in partial or total collapse of the lung.
- The escape of fluid into the pleural cavity (pleural effusion) is called hydrothorax. If the fluid is blood, the condition is known as a hemothorax, and if it is chyle from the thoracic duct, it is called a chylothorax.
- Inflammation of the pleurae is called pleuritis or pleurisy. Resulting friction between the two pleurae (pleural rub) is very painful and can be heard with a stethoscope.
- The inflamed pleurae may adhere to each other (pleural adhesion).
- Squamous cell or oat cell carcinoma is a common cancer of the lung, usually caused by smoking, that may be indicated by a persistent cough or spitting of blood (hemoptysis).

MEMORY AIDS

Let's **p**lay the **v**iolin: **L** = **l**ung pleura, **P** = **p**arietal **V** = **v**isceral

3 Ps: **P**arietal **P**leura innervated by the **P**hrenic nerve

Victor has no sensation: Visceral pleura has no sensory innervation

Causes of hilar lymphadenopathy: **T**ell **S**ome **L**ies: **T**uberculosis, **S**arcoidosis, **L**ymphoma

Bronchopulmonary segments: **A**pes **A**nd **P**ossums **M**ight **L**ight **LAMPS**: (Upper lobe: **A**pical, **An**terior, **P**osterior; Middle lobe: **M**edial and **La**teral; Lower lobe: **La**teral, **A**nterior, **M**edial, **P**osterior, **S**uperior)

3.5 HEART

Study Aims

At the end of your study, you should be able to:

- Identify the pericardium and its relationships
- Know the layers of the pericardium
- Understand the surface projection of the heart and its chambers
- Know the internal features of the atria and ventricles
- Understand coronary circulation
- Know the innervation and conduction system of the heart

GUIDES

PERICARDIUM

- The pericardium is a double-layered sac that encloses the heart and the roots of the great vessels.
- The fibrous outer layer of the pericardium (the fibrous pericardium) consists of dense connective tissue.
- The fibrous pericardium is attached to the central tendon of the diaphragm by the pericardiacophrenic ligament.
  - It blends with the tunica adventitia of the vessels entering and leaving the heart.
  - It has ligamentous attachments to the sternum.
  - It is thus affected by movements of the heart, great vessels, sternum, and diaphragm.
  - It protects the heart against overfilling because it is fibrous and unyielding.
- The inner layer of the pericardium is a serous membrane that lines the fibrous pericardium: the serous pericardium, also called the parietal pericardium.
- The serous pericardium is a mesothelial layer that reflects onto the roots of the great vessels and is continuous over the external surface of the heart, where it is called the epicardium or visceral pericardium.
- Between the serous pericardium (parietal pericardium) and the epicardium (visceral pericardium) is a potential space: the pericardial cavity.
- The pericardial cavity normally contains a thin film of fluid that allows the two layers to move over each other without friction or rubbing.
- There are two sinuses within the pericardial cavity: transverse and oblique.
  - The transverse pericardial sinus runs transversely in the pericardial sac between the origins of the great vessels: posterior to the ascending aorta and pulmonary trunk and anterior to the superior vena cava.
  - The oblique pericardial sinus is a wide recess in the posterior wall of the pericardial sac bounded laterally by the entrances of the pulmonary veins and inferiorly by the orifice of the inferior vena cava.
- Blood supply to the layers of the pericardium is mainly from the pericardiacophrenic vessels, from the internal thoracic arteries and veins.
- The nerve supply to the pericardium is from the phrenic nerves, primarily sensory fibers for pain, and the sympathetic trunks (vasomotor).

HEART

- The heart is a muscular pump for propulsion of blood to all parts of the body.
- The right side of the heart receives poorly oxygenated blood from superior and inferior vena cava and pumps it to the lungs for oxygenation.
- The left side of the heart receives oxygenated blood from the lungs via pulmonary veins and pumps it to the body via aorta and its branches.
- The heart consists of four chambers: right and left atria and right and left ventricles.
- The chambers of the heart have walls that consist of three layers.
  - Endocardium: internal layer of endothelium and connective tissue
  - Myocardium: middle, thick muscular layer of the heart
  - Epicardium, or visceral pericardium
- The fibrous skeleton of the heart is a framework of dense collagen that encircles orifices of the four valves (pulmonary, aortic, tricuspid and mitral).
- Functions of the fibrous skeleton
  - Maintains patency of atrioventricular valves
  - Provides a fixed site for attachment of leaflets and cusps of valves
  - Provides a fixed site for attachments of cardiac muscle fibers
  - Insulates atria from ventricles so that they can contract independently
- The cardiac cycle consists of
  - Relaxation of ventricles (diastole), followed by
  - Contraction of ventricles (diastole)
- Heart sounds heard with a stethoscope
  - "lub"—blood from the atria fills the ventricles
  - "dub"—ventricles contract and push blood out of the heart

Orientation of the Heart: Border and Surfaces

- The heart lies obliquely between 3rd and 5th ribs, mainly on left side of midline of thorax but with roughly a third of it slightly to right.
- The base of the heart is its posterior surface, which is the left atrium.
- The apex of the heart is formed from the most inferior and lateral part of the left ventricle and lies beneath the left 5th intercostal space at approximately the midclavicular line.

Borders.
- Right border: the right atrium between the superior and inferior vena cavae
- Left border: left auricle and left ventricle
- Inferior border: mainly right ventricle with some contribution from the left ventricle
- Superior border (anterior view): right and left atria and their auricles

Surfaces (in normal anatomical position).
- Anterior (sternocostal): right ventricle
- Diaphragmatic (inferior): mainly by the left ventricle with some contribution by the right ventricle
- Pulmonary surface (left, filling the cardiac impression in the left lung): left ventricle

Chambers of the Heart

Right Atrium.
- The posterior wall of the right atrium is smooth (sinus venarum) and contains the orifices of the superior vena cava and coronary sinus.
- The anterior wall is ridged with the pectinate muscles.
- The smooth and rough parts of the right atrium are separated internally by a smooth ridge, the crista terminalis, which presents externally as shallow groove, the sulcus terminalis.
- The superior vena cava opens into the superior aspect of the right atrium.
- The inferior vena cava opens into the inferior part, in a direct line with the superior vena cava.
- An interatrial septum separates the right and left atria.
- An oval depression in the interatrial septum, the fossa ovalis, represents the fetal foramen ovale and its valve.
- A right atrioventricular (AV) orifice opens into the right ventricle.

Right Ventricle.
- The right ventricle is situated in front and to the left of the right AV orifice.
- The interior has prominent muscular ridges, the trabeculae carneae.
- The tricuspid valve or right AV valve consists of three leaflets.
  - The bases of the leaflets or cusps are attached to the fibrous ring around the orifice.
  - The free edge of each leaflet is attached to two of the three papillary muscles by tendinous cords (chordae tendineae).
- The papillary muscles are three in number: septal, anterior, and posterior.
- These muscles contract before the ventricle itself contracts, tightening the chordae tendinea and drawing the cusps of the valve together to prevent backflow of blood into the right atrium.
- The septomarginal trabecula, or moderator band, is a free band of muscle extending from the interventricular septum to the anterior wall of the ventricle, and it contains Purkinje fibers from the right bundle branch *(see Innervation and Conducting System of Heart).*
- The outflow tract of the ventricle is separated from the inflow tract by a smooth crest, the supraventricular crest.
- The outflow tract, or conus arteriosus, is smooth walled and leads to the pulmonary trunk and the valve that guards its orifice, the pulmonary valve.
- The pulmonary valve has three cusps, which open like pockets to catch regurgitated blood during ventricular diastole.

Left Atrium.
- The left atrium forms the base of the heart.
- It has a smooth-walled portion from the developmental incorporation of a portion of the pulmonary veins and an auricular appendage that is ridged with pectinate muscles and that was the primitive left atrium.
- Four pulmonary veins empty into the left atrium.
- The interatrial septum is nearly transverse, sloping posteriorly and to the right.
- The left atrioventricular orifice leads to the left ventricle.

Left Ventricle.
- The left ventricle is nearly twice as thick as the right ventricle, since it performs more work to circulate blood to the body.
- It has a conical cavity, the apex of which is the apex of the heart.
- Its walls are lined with trabeculae carnea, which are more numerous and not as massive as the ones in the right ventricle.
- It contains only two papillary muscles, anterior and posterior, which both attach to the two leaflets of the left atrioventricular, or mitral, valve via chordae tendinea.
- These muscles contract before the ventricle itself contracts, tightening the chordae tendinea and drawing the cusps of the valve together to prevent backflow of blood into the left atrium.
- The aortic orifice is located posteriorly and superiorly and, like the pulmonary orifice, is surrounded by a fibrous ring to which the three cusps of the aortic valve are attached.
- The aortic valve has three cusps, which open like pockets to catch blood that backflows from the aorta during ventricular diastole.
- There are dilations in the wall of the aorta beneath each cusp: the aortic sinuses.
- The right coronary artery originates in the right aortic sinus, while the left coronary artery originates in the left aortic sinus.

Coronary Circulation

Arteries.
- The arterial supply to the heart is the right and left coronary arteries, the first branches of the aorta.
- They arise from the corresponding aortic sinuses, just distal to the origin of the aortic valve.
- The left coronary artery passes between the left auricle and the pulmonary trunk, and its main branches are
  - A circumflex branch, which reaches the posterior surface of the heart by traveling in the atrioventricular groove around the left side of the heart
    - In slightly less than half of all people, a sinoatrial (SA) nodal branch from the circumflex branch will supply the SA node

  - An anterior interventricular branch (left anterior descending artery or LAD), which descends in the anterior interventricular groove to the apex of the heart. In some people the anterior interventricular artery anastomoses with the posterior interventricular artery.
- The right coronary artery runs in the atrioventricular groove to the right and around to the posterior surface of the heart and gives rise to
  - The SA nodal branch near its origin (in most people)
  - A right marginal branch to the right margin of the heart
  - An AV nodal branch to the atrioventricular node, at the junction of the septa and four chambers of the heart (crux) on the posterior side of the heart
  - A posterior interventricular branch that runs in the posterior interventricular groove
- The left coronary artery supplies
  - Left atrium
  - Most of left ventricle
  - Some of right ventricle
  - Interventricular septum
  - SA node (40% of people)
- The right coronary artery supplies
  - Right atrium
  - Most of right ventricle
  - Diaphragmatic surface of left ventricle
  - Some of the interatrial and interventricular septa
  - SA node (60% of people)
  - AV node

Veins.

- The coronary sinus is a wide vein that runs transversely across the posterior surface of the heart in the coronary groove.
- The coronary sinus receives blood from
  - The great cardiac vein that ascends in the anterior interventricular groove and enters the coronary sinus at its left end
  - The middle cardiac vein (posterior interventricular vein) that ascends in the posterior interventricular groove and enters the coronary sinus at its right end
  - Small cardiac veins
  - Left marginal vein
  - Left posterior ventricular vein(s)
- Anterior cardiac veins that enter the right atrium directly
- Venae cordis minimae (smallest cardiac veins) that open directly into the chambers of the heart

Innervation and Conducting System of the Heart

- Both divisions of the autonomic nervous system provide fibers to the cardiac plexus.
- The conducting system of the heart coordinates the cardiac cycle of contraction and consists of
  - The sinoatrial node (SA node), located at the superior end of the sulcus terminalis of the right atrium, near the entrance of the superior vena cava
  - The SA node is the so-called pacemaker of the heart, from which impulses for contraction are initiated and spread through the musculature of both atria.
- Fibers from the cardiac plexus supply the SA node.
  - Sympathetic innervation accelerates the rate and force of contraction of heart muscle.
  - Parasympathetic stimulation slows down the rate and force of contraction of heart muscle.
- Signal from the SA node is propagated by the cardiac muscle to the AV node.
- The AV node is located near the inferior end of the interatrial septum posteriorly, near the septal cusp of the tricuspid valve.
- The AV bundle carries the signal from the AV node through the fibrous skeleton of the heart and the membranous interventricular septum.
  - It divides into right and left bundles that pass on either side of the muscular interventricular septum.
  - The fibers of the right and left bundles (Purkinje fibers) spread into the walls and papillary muscles of the ventricles.
  - Purkinje fibers from the right bundle innervate the anterior papillary muscle of the right ventricle via the septomarginal trabecula or moderator band to coordinate the timing of the contraction of the papillary muscles.

Heart Sounds

- Clinicians need to listen to valve sounds.
- Blood carries sound in the direction of its flow, so valve sounds are best heard (auscultated) directly superficial to their location or at the end of a line of blood flow through the valve.

CLINICAL POINTS

CARDIAC TAMPONADE

- Inflammation of the pericardium (pericarditis) can result in pericardial effusion, a leakage of fluid from the pericardial capillaries into the pericardial cavity.
- Similarly, stab wounds to the heart can result in the leakage of blood into the pericardial cavity.
- As excess blood or fluid accumulates in the pericardial cavity, the heart becomes increasingly inhibited from expanding as it beats, and blood flow to the ventricles is impeded.
- This situation is called cardiac tamponade and is a potentially lethal condition.
- Symptoms include distension of neck veins and a collapsing pulse (i.e., diastolic and systolic pressures become the same).

PERICARDIOCENTESIS

- Pericardiocentesis or drainage of fluid from the pericardial cavity is necessary to relieve cardiac tamponade.
- A wide-bore needle is inserted into the 5th or 6th intercostal space adjacent to the sternum under the guidance of an ultrasound* (but not too close because of the presence of the internal thoracic vessels).
- This approach can be made because of the cardiac notch in the left lung and left parietal pleura, leaving the pericardial sac exposed.

*It is protocol in the US that all pericardiocentesis procedures be performed under the guidance of ultrasound.

- A needle can also be inserted into the infrasternal angle, again being careful of the internal thoracic artery and its branches, and passed superiorly and posteriorly to reach the pericardial sac.

CARDIAC-REFERRED PAIN

- While the heart is generally insensitive to various stimuli, ischemia (lack of oxygen) and the resulting accumulation of metabolic products registers as pain, typically in the left pectoral and substernal regions and over the medial aspect of the left shoulder and upper limb.
- The axons of visceral afferent fibers from the heart typically enter spinal cord segments from T1 through T4 or 5 on the left side.
- General sensory fibers from these areas also enter the same spinal cord segments.

CARDIAC BYPASS GRAFT (CABG)

- In this surgery, the patient has a blood vessel grafted into the coronary circulation to bypass an occlusion in one of the coronary arteries or its branches.
- In the past, the saphenous vein was commonly used in the bypass graft because it is easily obtained from the lower limb and has lengthy sections without valves or branches.
- The internal thoracic and the radial arteries are more frequently used to shunt blood from the aorta to branches of the coronary arteries beyond the occlusion.
- This restores normal blood flow to the part of the heart distal to the blockage.

VENTRICULAR SEPTAL DEFECTS (VSDS)

- The membranous part of the interventricular septum is the most common site of ventricular septal defects (VSDs).
- VSDs account for 25% of all cardiac abnormalities.
- It can be a result of any one of several developmental anomalies, such as failure of the embryonic endocardial cushions, which form part of the septum, to fuse.
- A left to right flow of blood occurs with this defect because of the strength of contraction of the left ventricle.
- This increases the blood flow through the pulmonary trunk to the lungs and results in pulmonary hypertension (increased blood pressure) and an enlarged heart.
- This condition is potentially fatal if not corrected.

PATHOLOGIES OF THE AORTA

- An aortic aneurysm is an enlargement of a weakened area of the aorta, in this case in the distal part of the ascending aorta.
- Aneurysms are prone to rupture once they reach a certain size, and 50% of patients who experience a rupture of a thoracic aortic aneurysm die before reaching the hospital.
- Ascending aortic aneurysms frequently cause dilation and leakage of the aortic valve, resulting in shortness of breath or even heart failure.
- They can also cause a dull pain beneath the sternum and/or pain radiating to the upper back.
- Aortic dissection is a tearing of the internal wall of the aorta, with subsequent bleeding into the wall, as the result of an aneurysm, atherosclerosis, or high blood pressure.
- Coarctation of aorta is a birth defect in which the descending thoracic aorta is narrowed somewhere along its length, most commonly distal to the remnants of the ductus arteriosus (juxtaductal).
- This results in low blood pressure in branches of the aorta distal to the narrowing and high blood pressure in branches between the narrowing and the heart.
- People with this condition often have high blood pressure in the upper body and arms (or one arm) and low blood pressure in the lower body and legs.
- The intercostal arteries can become enlarged, since the anastomoses of the anterior intercostals (from the internal thoracic artery) with the posterior intercostals can circumvent the narrowing.
- Aortic coarctation is more common in some genetic conditions such as Turner syndrome but also can be associated with congenital conditions of the aortic valve such as a bicuspid aortic valve.

VALVULAR INSUFFICIENCIES

- The mitral valve is the heart valve most frequently affected by disease.
- It can be caused by endocarditis, myocarditis, rheumatic heart disease, or systemic lupus erythematosus, or can result from a developmental abnormality.
- The diseased mitral valve allows reversal of blood flow from the left ventricle to the left atrium (mitral regurgitation).
- It is characterized by a high-pitched murmur, loudest over the apex of the heart.
- Narrowing of the pulmonary valve (stenosis) is caused by fusion of the valve cusps.
- It can result from a developmental anomaly or diseases such as rheumatic fever or endocarditis.
- Stenosis of the pulmonary valve leads to right ventricular hypertrophy and heart failure if not corrected surgically.

MEMORY AIDS

PV2L: Pulmonary valve heard over 2nd left intercostal space
AV2R: Aortic valve heard over 2nd right intercostal space
To remember the cusps of the aortic and pulmonary valves:
A = P and **P = A**
A(ortic) = **P**osterior, Right and Left
P(ulmonary) = **A**nterior, Right and Left

3.6 MEDIASTINUM

Study Aims

At the end of your study, you should be able to:

- Identify the mediastinum
- Identify the major arteries and veins of the mediastinum
- Identify the trachea
- Identify the esophagus

GUIDES

GENERAL DESCRIPTION

- The mediastinum is the central compartment of the thorax between the two pleural cavities.
- Stretches from thoracic inlet to diaphragm and from sternum to bodies of thoracic vertebrae posteriorly.
- Its contents include the heart, trachea, esophagus, great vessels of the heart, lymph nodes, nerves, and fat.
- The mediastinum is divided into two parts.
  - The superior part extends from thoracic inlet to a plane at level of sternal angle and T4/5 intervertebral disc.
  - The inferior mediastinum extends from this plane to the diaphragm.
- Superior mediastinum contains the
  - Superior vena cava
  - Arch of the aorta and its branches
  - Trachea
  - Phrenic nerves
  - Thoracic duct
  - Esophagus
  - Vagus nerves
  - Left recurrent laryngeal nerve
  - Thymus
- Inferior mediastinum is subdivided into
  - Anterior mediastinum
  - Middle mediastinum
  - Posterior mediastinum
- The anterior mediastinum contains fat and remnants of thymus gland.
- The middle mediastinum contains the heart surrounded by the pericardium and the roots of the great vessels. The great vessels are
  - Ascending aorta
  - Superior vena cava
  - Pulmonary trunk
- The posterior mediastinum contains
  - Esophagus and the esophageal plexus
  - Descending aorta
  - Thoracic duct
  - Tracheobronchial lymph nodes
  - Azygos and hemi-azygos veins
  - Thoracic sympathetic trunks
  - Thoracic splanchnic nerves

STRUCTURES IN THE MEDIASTINUM

- Thymus gland
  - Plays a central role in development of immune system
  - Lies posterior to manubrium
  - Receives blood from internal thoracic and anterior intercostal arteries
  - Is gradually replaced by adipose tissue after puberty
- Heart and pericardial sac (see *section 3.5, Thorax—Heart*)
- Superior vena cava
  - Formed by union of two brachiocephalic veins
  - Returns blood to the heart from all structures above the diaphragm except the heart and lungs
  - Descends vertically and terminates in right atrium
  - Lies to the right of ascending aorta and to the left of right phrenic nerve
  - Receives azygos veins before piercing fibrous pericardium
- Brachiocephalic veins
  - Are formed in the root of the neck posterior to sternoclavicular joints by union of internal jugular and subclavian veins
  - Right brachiocephalic vein
    - Receives lymph from right lymph duct
    - Is accompanied by right phrenic vein
  - Left brachiocephalic vein
    - Is twice as long as the right
    - Runs obliquely down and behind the manubrium
    - Crosses roots of three major branches of aorta
    - Receives lymph from thoracic duct
- Aorta
  - Ascending
    - Begins at aortic orifice
    - Ascends to 2nd right sternocostal joint
  - Arch
    - Begins at 2nd right sternocostal joint and arches superiorly and to the left
    - Anterior to right pulmonary artery and bifurcation of trachea
    - Passes over root of right lung
    - Ends at body of T4 vertebra
  - Descending (thoracic)
    - Begins at body of T4 vertebra
    - Descends on left side of bodies of T5–12 vertebrae, posterior to root of left lung and pericardium
    - Enters abdomen through aortic hiatus at T12 vertebral body
    - Has a number of branches
      - Bronchial (1–2)
      - Pericardial (twigs)
      - Superior phrenic (1 pair)
      - Esophageal (2)
      - Posterior intercostal (9 pairs)
      - Subcostal (1 pair)
- Trachea
  - Continues from larynx
  - Contains cartilaginous semicircular rings
  - Is completed by muscle posteriorly
  - Descends anterior to esophagus, slightly to right of midsagittal plane
  - Bifurcates into right and left main bronchi at level of T4/T5 (angle of Louis)
  - Right bronchi divides into upper and lower lobar bronchi before entering right lung
- Esophagus
  - Is a fibromuscular tube from pharynx to stomach
  - Contains both circular and longitudinal muscles, both skeletal and smooth
    - Upper 1/3—skeletal muscle
    - Lower 2/3—smooth muscle
  - Passes through right crus of diaphragm at T10
  - Continues for 1–2 cm below diaphragm
  - Supplied by esophageal plexus of nerves derived from
    - Right and left vagal nerves
    - Sympathetic nerves
  - Surrounded by a number of lymph nodes
    - Inferior deep cervical nodes
    - Posterior mediastinal nodes

    - Intercostal nodes
    - Paratracheal nodes
    - Superior and inferior tracheobronchial nodes
  - Vascular supply
    - Arterial: esophageal branches of thoracic aorta venous: azygos, hemi-azygos, and accessory azygos veins
- Thoracic duct
  - Originates from cisterna chili in abdomen
  - Contains valves
  - Ascends through aortic hiatus in diaphragm
  - Lies anterior to bodies of T6–12 vertebral bodies, between thoracic aorta and azygos vein
  - Conveys lymph from limbs, pelvic and abdominal cavities, left side of thorax, left upper limb, and left side of head and neck
  - Empties into venous system at junction of left internal jugular and left subclavian veins
- Azygos venous system
  - Drains blood from back and thoracoabdominal walls
  - Highly variable
  - Composed of an unpaired azygos vein and its main tributary, the hemi-azygos vein
  - Offers an alternate route for blood to reach the heart if inferior vena cava is blocked
  - Azygos vein
    - Arises from ascending lumbar and/or renal veins and subcostal veins
    - Ascends on right side of bodies of T5–T12 vertebrae
    - Arches over root of right lung to join superior vena cava
    - Receives blood from
      - Hemi-azygos vein
      - Posterior intercostals veins
      - Esophageal veins
      - Bronchial veins
      - Communications with vertebral venous plexus
  - Hemi-azygos vein
    - Arises from left subcostal and ascending lumbar veins
    - Ascends on left side of vertebral column from T12–T9
    - Crosses T9 vertebrae posterior to aorta, esophagus and thoracic duct to empty into azygos vein
    - Receives blood from
      - Inferior three posterior intercostals
      - Inferior esophageal veins
      - Accessory hemi-azygos (occasionally)
  - Accessory hemi-azygos vein
    - Begins at 4th or 5th intercostal space on left
    - Descends on left side of vertebrae T5–T8
    - Crosses over T7 or T8 vertebrae to join azygos
    - Sometimes joins hemi-azygos
    - Receives blood from
      - Posterior intercostal veins from 4th through 8th intercostal spaces
      - Left superior intercostal vein (occasionally)
- Vagus nerves and recurrent laryngeal nerves
  - Right vagus nerve
    - Enters thorax anterior to right subclavian artery and immediately gives rise to right recurrent laryngeal nerve, which loops around right subclavian artery and ascends into the neck
    - Descends on right side of trachea
    - Passes posterior to right brachiocephalic vein, superior vena cava and root of right lung
    - Gives rise to branches of right pulmonary plexus
    - Continues to esophagus, where it contributes to esophageal nerve plexus and continues as anterior vagal trunk into abdomen
  - Left vagus nerve
    - Enters mediastinum between left common carotid and left subclavian arteries
    - Descends with left phrenic nerve to aortic arch
    - Gives off left recurrent laryngeal nerve just below arch, which loops around arch and ascends into the neck
    - Passes posterior to root of left lung where it contributes to left pulmonary plexus
    - Continues as a single nerve to esophagus where it contributes to esophageal nerve plexus and continues as posterior vagal trunk into abdomen
- Phrenic nerves
  - Supply motor and sensory fibers to diaphragm
  - Enter superior mediastinum between subclavian artery and brachiocephalic vein on either side
  - Pass anterior to roots of lungs, unlike vagus nerve
  - The right phrenic nerve descends on right side of inferior vena cava to diaphragm
  - The left phrenic nerve
    - Crosses arch of aorta
    - Descends anterior to root of left lung and along pericardium over left atrium and ventricle
    - Pierces diaphragm to left of pericardium
- Thoracic sympathetic trunks
  - Continuous with cervical and lumbar sympathetic trunks
  - Shift medially as they descend, crossing from heads of ribs to costovertebral joints to sides of vertebral bodies
  - Give off paired thoracic splanchnic nerves
    - Greater splanchnic: from T5–T9 vertebral levels
    - Lesser splanchnic: from T10–T11 vertebral levels
    - Least splanchnic: from T12 vertebral level

CLINICAL POINTS

RECURRENT LARYNGEAL NERVE INJURY

- The recurrent laryngeal nerve supplies all of the intrinsic muscles of the larynx but one.
- Surgery, injury, or disease affecting the contents of superior mediastinum can damage either or both recurrent laryngeal nerves, reducing the voice to a hoarse whisper.
- The left recurrent laryngeal nerve passes beneath the arch of the aorta and ascends to the neck between the trachea and the esophagus at the tracheoesophageal groove. Bronchogenic or esophageal carcinoma or an aneurysm of the arch of the aorta can thus affect this nerve.

CHYLOTHORAX

- Surgical procedures involving the posterior mediastinum can injure the thoracic duct, which is hard to identify because it has a thin wall and is usually colorless.

- Injury to the thoracic duct can lead to leakage of lymph into the thoracic cavity at a volume of up to 200 mL per hour.
- Lymph is called chyle when it is carrying chylomicrons (fat droplets) from the digestion of food in the gastrointestinal system.
- If lymph from the thoracic duct enters the pleural cavity, the resulting condition is called a chylothorax and may require removal by thoracocentesis.

MEMORY AIDS

Spinal nerve contributions to the phrenic nerve: **C3,4,5 keeps the diaphragm alive**

8-10-12:
T**8**—Site at which inferior vena cava pierces the diaphragm
T**10**—Site at which esophagus pierces the diaphragm
T**12**—Site at which aorta pierces the diaphragm

SAT (for major contents of the **s**uperior mediastinum): **S**uperior vena cava, **A**rch of aorta, and **T**rachea

Turkeys **B**low **E**ggs: **T**rachea lies **B**ehind the **E**sophagus

Relationship of thoracic duct to esophagus and azygos vein
"The duck lies between two gooses." (*duck* = thoracic duct)
Two gooses = azyGOOSE and esophaGOOSE

4 Abdomen Study Guide

4.1 TOPOGRAPHIC ANATOMY

Study Aims

At the end of your study, you should be able to:

- Understand the boundaries of the abdominal cavity
- Identify surface landmarks of the abdomen
- Know the four quadrants of the abdomen and their contents
- Know the nine regions of the abdomen
- Know the lines and planes that create the four quadrants and nine regions

GUIDE

ABDOMEN—OVERVIEW

- Lies between the diaphragm and pelvic inlet
- Largest cavity in the body and is continuous with pelvic cavity
- Lined with parietal peritoneum, a serous membrane
- Bounded superiorly by the diaphragm
  - Has concave dome
  - Spleen, liver, part of stomach, and part of kidneys lie under dome and are protected by lower ribs and costal cartilages.
- Lower extent lies in greater pelvis.
  - Between ala or wings of ilia
  - Ileum, cecum, and sigmoid colon thus partly protected
- Anterior and lateral walls composed of muscle
  - Viscera in these areas are more likely to be damaged by blunt force and penetrating injuries.
- Posterior wall made up of vertebral column, lower ribs, and associated muscles
  - Protect abdominal contents

Bony Landmarks of the Abdomen

- Xiphoid process
- Lower six costal cartilages
- Anterior ends of lower six ribs (ribs 7 to 12) *(see Section 3.3, Thorax—Body Wall)*
- Lumbar vertebrae (L1 to L5)
- Pelvis
  - Iliac crest
  - Anterior superior iliac spine (ASIS)
  - Anterior inferior iliac spine
  - Pubic symphysis
  - Pubic crest and pubic tubercle
- Costal margin: formed by medial borders of 7th through 10th costal cartilages
- Rectus sheath
  - From xiphoid process and 5th through 7th costal cartilages → pubic symphysis and pubic crest
  - Contains rectus abdominis muscle *(see Section 4.2, Abdomen—Body Wall)*
- Linea alba
  - Slight indentation that can sometimes be seen extending from xiphoid process to pubic symphysis
  - Fibrous raphe where aponeuroses of external and internal abdominal oblique and transversus abdominis muscles on either side unite
- Semilunar line (linea semilunaris)
  - Vertical indentation seen as curved line from tip of 9th rib cartilage to pubic tubercle on each side in well-muscled individuals
  - Represents lateral edge of rectus abdominis muscle
- Tendinous intersections
  - Transverse attachments between anterior rectus sheath and rectus abdominis muscle
  - May be seen as transverse grooves in skin on either side of midline ("six-pack")
- Inguinal ligament
  - From ASIS to pubic tubercle of pelvis
  - Folded inferior edge of external abdominal aponeurosis
  - Separates abdominal region from thigh
- Umbilicus
  - At approximate level of intervertebral disc between the L3 and L4
  - Marks the T10 dermatome
- Liver
  - Mainly in right upper quadrant, behind ribs 7 through 11 on right side
  - Crosses midline to reach toward left nipple *(see Section 4.5, Abdomen—Viscera [Accessory Organs])*
- Spleen
  - Beneath ribs 9 through 11 on left side
  - 10th rib is axis of spleen

- Kidneys
  - Located in loin region
  - Left kidney higher than right (pelvis at L1/2 on left and L2/3 on right) *(see Section 4.8, Abdomen—Kidneys and Suprarenal Glands)*

Abdominal Contents

- Gastrointestinal tract
  - Stomach
  - Duodenum
  - Ileum
  - Jejunum
  - Cecum and appendix
  - Ascending, transverse, and descending colon
  - Part of sigmoid colon
- Accessory digestive organs
  - Liver
  - Gallbladder
  - Pancreas
- Spleen
- Suprarenal glands
- Urinary system—kidneys and ureters
  - Kidneys are only organs developing beneath the parietal peritoneum.
  - Never have a mesentery
  - Thus are primarily retroperitoneal
- Organs that develop within abdominal cavity and then become retroperitoneal
  - Referred to as secondarily retroperitoneal
  - Pancreas
  - Two thirds of duodenum
  - Ascending and descending colon
- All the rest of the organs are peritoneal
  - Lie within peritoneal cavity
  - Covered by layer of visceral peritoneum
  - Visceral peritoneum is continuous with parietal peritoneum lining cavity via a mesentery.

Abdominal Quadrants and Regions

- Abdominal quadrants
  - Clinicians usually divide the abdomen is into four quadrants for descriptive purposes, using the following planes:
    - Median plane: imaginary vertical line following line alba from xiphoid process to pubic symphysis
    - Transumbilical plane: imaginary horizontal line at level of umbilicus
  - These lines or planes create four quadrants
    - Right upper
    - Left upper
    - Right lower
    - Left lower
- Abdominal regions
  - Clinicians may divide the abdomen into nine regions
    - For more accurate descriptive and diagnostic purposes
    - Use two vertical and three horizontal lines or planes
  - Horizontal planes (in descending order):
    - *Subcostal plane*: passes through lower border of 10th costal cartilage on either side
    - Sometimes *transpyloric plane* is used instead of subcostal; passes through pylorus on right and tips of 9th costal cartilage on either side
    - *Transumbilical plane*: passes through umbilicus at level of L3/4 intervertebral disc
    - *Transtubercular (intertubercular) plane*: passes through tubercles of iliac crests and the body of L5
  - Vertical planes
    - Right midclavicular line
    - Left midclavicular line
    - Pass from midpoint of clavicle to midpoint of inguinal ligament.
  - These planes create nine abdominal regions:
    - Right and left hypochondriac regions, superiorly on either side
    - Right and left lumbar (flank) regions, centrally on either side
    - Right and left inguinal (groin) regions, inferiorly on either side
    - Epigastric region superiorly and centrally
    - Umbilical region, with umbilicus as its center
    - Hypogastric or suprapubic region, inferiorly and centrally
- Descriptive quadrants and regions are essential in clinical practice.
  - Each area represents certain visceral structures
  - Allow correlation of pain and referred pain from these areas to specific organs.
- Regions and quadrants are palpated, percussed, and auscultated during clinical examination.

Contents of the Abdominal Quadrants

Right Upper Quadrant (RUQ)	Left Upper Quadrant (LUQ)
Liver (right lobe)	Liver (left lobe)
Gallbladder	Spleen
Pylorus (of stomach)	Stomach
Duodenum (parts 1 through 3)	Jejunum and proximal ileum
Pancreas (head)	Pancreas (body and tail)
Right kidney and suprarenal gland	Left kidney and suprarenal gland
Colon: distal ascending colon, hepatic flexure and right half of transverse colon	Colon: left half of transverse colon, splenic flexure and superior part of descending colon
Right Lower Quadrant (RLQ)	**Left Lower Quadrant (LLQ)**
Majority of ileum	Distal descending colon
Cecum with vermiform appendix	Sigmoid colon
Proximal ascending colon	Left ureter
Proximal right ureter	
Ovaries	
Uterine tubes	
Right and left ductus deferens	
Uterus (if enlarged)	
Urinary bladder (if full, especially in women)	

CLINICAL POINTS

MCBURNEY'S POINT AND APPENDICITIS

- **McBurney's point** is a surface landmark that roughly indicates the location of the appendix, located approximately one third of the way along a line from the anterior superior iliac spine to the umbilicus.
- **Appendicitis** is inflammation of the appendix. Pain first presents in the epigastric region, moves to the umbilical region, and then localizes in the right lower quadrant. Rupture of the appendix leads to peritonitis (inflammation of the peritoneum). This presents with severe pain, fever, and abdominal rigidity.
- **Muscle-splitting incision (of McBurney)** is used to access the appendix. Each muscle layer is split in the direction of the fiber orientation. If the incision extends too far laterally the ascending branch of the deep circumflex iliac artery may be severed.

GREY-TURNER'S SIGN

- Local right flank redness or bruising (ecchymosis)
- Indicates retroperitoneal hemorrhage
- Usually takes 24 to 48 hours to appear
- Can be predictive of severe hemorrhagic pancreatitis, abdominal injury, or metastatic cancer

CULLEN'S SIGN

- Discoloration (ecchymosis) around umbilicus
- Result of peritoneal hemorrhage

MEMORY AIDS

Causes for abdominal expansion (protuberance)
Remember the **five F's:**

Fat
Feces
Fetus
Flatus
Fluid

4.2 BODY WALL

Study Aims

At the end of your study, you should be able to:

- Know the layers of the anterior abdominal wall from superficial to deep
- Understand the orientation and functions of the muscles of the anterolateral abdominal wall
- Describe the structure of the rectus sheath and its contents
- Describe the neurovascular supply of the abdominal wall
- Understand the boundaries of the inguinal canal and layers of the spermatic cord
- Describe the boundaries of Hesselbach's triangle
- Know the etiology and location of the umbilical peritoneal folds
- Understand the structure and organization of the posterior abdominal wall and its neurovascular relations

GUIDE

ANTEROLATERAL ABDOMINAL WALL

Fascial Layers

- Superficial fascia: two layers in abdomen
- Fatty superficial layer (Camper's fascia)
- Deeper membranous layer (Scarpa's fascia)
- Deep fascia—very thin layer investing most superficial muscles
- Transversalis fascia (endoabdominal fascia)
  - Thin membranous sheet lining most of abdominal wall
  - Lies deep to transversus muscles and linea alba
- Endoabdominal fat separates the transversalis fascia from the parietal peritoneum.

Muscles

- Functions
  - Protect viscera
  - Help maintain posture
  - Can compress abdominal contents, thus raising intra-abdominal pressure, such as in sneezing, coughing, defecating, micturating, lifting, and childbirth
- Four paired muscles make up anterolateral abdominal wall: three flat muscles and single vertical muscle.
- Three flat muscles
  - External abdominal oblique
    - Largest and most superficial
    - Fibers run inferiorly and medially and end in aponeurosis that contributes to rectus sheath.
    - Inferior border of its aponeurosis forms inguinal ligament, where it thickens and folds back on itself.
    - Innervated segmentally by T6–T12 spinal nerves and subcostal nerve
  - Internal abdominal oblique
    - Thin muscular layer
    - Fibers run inferiorly and laterally and end in an aponeurosis that contributes to rectus sheath.
    - Inferior aponeurotic fibers join with those of rectus abdominis to form conjoint tendon, inserting onto pubic crest.
    - Innervated segmentally by ventral rami of T6–T12 spinal nerves
  - Transversus abdominis
    - Innermost of three flat muscles
    - Fibers run transversely and medially and end in an aponeurosis that contributes to rectus sheath.
    - Innervated segmentally by ventral rami of T6–T12 spinal nerves
  - Linea alba
    - Tendinous raphe running vertically in midline
    - Formed by union of aponeuroses of flat muscles on either side
    - Largely avascular
    - Umbilicus found in midline
- Vertical muscle = *rectus abdominis*
  - Paired
  - Separated by linea alba in midline
  - Wider superiorly than inferiorly
  - Typically composed of four segments connected by tendinous intersections that attach anteriorly to sheath of this muscle

- Innervated segmentally by ventral rami of T6–T12 spinal nerves
- Have the superior epigastric and inferior epigastric arteries running inferiorly and superiorly, respectively, on their deep surfaces.

- Pyramidalis muscle
  - Small, insignificant, triangular muscles arising from body of pubis inferiorly
  - Inserts into linea alba medially
  - Absent in 20% of people

Rectus Sheath

- Tough, fibrous sheath composed of aponeuroses of three flat muscles
  - Extends from xiphoid process and 5th through 7th costal cartilages to pubic symphysis and crests
  - Contains superior and inferior epigastric vessels, lymphatics, and branches of ventral primary rami of T7–T12
  - Encloses rectus abdominis and pyramidalis muscles
  - Semilunar line marks lateral border.
- Has crescent-shaped line—the arcuate line—on its posterior wall approximately three fourths of way down wall.
- Above arcuate line
  - Anterior wall composed of aponeurosis of external abdominal oblique and anterior layer of aponeurosis of internal abdominal oblique.
  - Posterior wall composed of posterior layer of aponeurosis of internal abdominal oblique, aponeurosis of transversus abdominis, transversalis fascia of abdomen, and parietal peritoneum.
- Below arcuate line
  - Aponeuroses of all three flat muscles pass anterior to rectus muscle, reinforcing anterior wall.
  - Posterior wall composed of just transversalis fascia and parietal peritoneum.
- Vessels and nerves enter sheath at its lateral edge—the semilunar line—to supply rectus muscle.

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
External oblique	External surfaces of ribs 5–12	Linea alba, pubic tubercle, and anterior half of iliac crest	Ventral rami of six inferior thoracic nerves	Compresses and supports abdominal viscera; flexes and rotates trunk	Superior and inferior epigastric arteries
Internal oblique	Thoracolumbar fascia, anterior 2/3 of iliac crest, lateral half of inguinal ligament	Inferior borders of ribs 10–12, linea alba, pubis via conjoint tendon	Ventral rami of inferior six thoracic and 1st lumbar nerves	Compresses and supports abdominal viscera; flexes and rotates trunk	Superior and inferior epigastric and deep circumflex iliac arteries
Transversus abdominis	Internal surfaces of costal cartilages 7–12, thoracolumbar fascia, iliac crest, and lateral third of inguinal ligament	Linea alba with aponeurosis of internal oblique, pubic crest, and pecten pubis via conjoint tendon	Ventral rami of inferior six thoracic and first lumbar nerves	Compresses and supports abdominal viscera	Deep circumflex iliac and inferior epigastric arteries
Rectus abdominis	Pubic symphysis and pubic crest	Xiphoid process and costal cartilages 5–7	Ventral rami of inferior six thoracic nerves	Flexes trunk and compresses abdominal viscera	Superior and interior epigastric arteries
Pyramidalis	Body of pubis, anterior to rectus abdominis	Linea alba	Iliohypogastric nerve	Tenses linea alba	Inferior epigastric artery

Innervation

- Neurovascular plane
  - Found between internal abdominal oblique and transversus abdominis
  - Contains vessels and nerves supplying skin and muscles of anterior and lateral abdominal wall.
  - Nerves and vessels are transversely oriented and segmental
- Nerves
  - Thoracoabdominal nerves
  - Anterior cutaneous branches of ventral primary rami of T7–T11
    - T7–T9 supply skin above umbilicus
    - T10 supplies skin around umbilicus
    - T11 (plus subcostal and ilio-inguinal and iliohypogastric nerves) supplies skin below umbilicus
  - Subcostal nerves (T12) supply skin below umbilicus
  - Iliohypogastric and ilio-inguinal nerves (terminal branches of L1) supplies skin below umbilicus

Vascular Supply

- Arteries
  - Anterior and collateral branches of posterior intercostal arteries
  - Branches of internal thoracic arteries
    - Superior epigastric
    - Musculophrenic
  - Inferior epigastric (from external iliac)

- Branches of femoral artery
  - Superficial epigastric
  - Superficial circumflex iliac
- Veins
  - Venous drainage is via venae comitantes (veins corresponding to the arteries listed).
  - Blood drains away from umbilicus
  - Venous drainage to caval system
- Lymphatics
  - Superficial lymphatics above umbilicus lymph drain to axillary nodes.
  - Superficial lymphatics below umbilicus drain to superficial inguinal nodes.
  - Deep lymphatics
    - Accompany deep veins
    - Drain to external iliac, common iliac, and lumbar nodes

POSTERIOR ABDOMINAL WALL

Fascial Layers

- Superficial fascia: single layer
- Deep fascia— very thin layer investing the most superficial muscles
- Transversalis fascia (endoabdominal fascia)
- Endoabdominal fat separates transversalis fascia from parietal peritoneum
- Psoas sheath
  - Fascia covering psoas muscle
  - Attaches to lumbar vertebrae and pelvic brim
  - Thickened superiorly to form medial arcuate ligament— site of origin of muscle of diaphragm
- Fascia of quadratus lumborum
  - Fuses medially with psoas fascia
  - Thickened superiorly to form lateral arcuate ligament— site of origin of muscle of diaphragm
- Thoracolumbar fascia (*see Section 2, Back and Spinal Cord*)
  - Composed of anterior and posterior layers
  - Encloses deep muscles of the back
  - Thick and strong in lumbar region
  - Extends from 12th rib to iliac crest and continuous laterally with deep fascia of internal oblique and transversus abdominis muscles

Muscles

- Psoas major
  - Long and thick
  - Lies lateral and is attached to lumbar vertebrae
  - Tendon passes deep to inguinal ligament to lesser trochanter of femur
  - Together with iliacus forms iliopsoas muscle, which flexes the hip, helps maintain erect posture
  - Lumbar plexus of nerves embedded within it
- Iliacus
  - Attaches to superior two thirds of iliac fossa
  - Joins psoas to form iliopsoas
- Quadratus lumborum
  - Thick quadrangular muscle of posterior wall
  - Extends from 12th rib and tips of lumbar transverse processes to iliac crest
  - Flexes and laterally extends vertebral column

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Psoas major	Transverse processes of lumbar vertebrae, sides of bodies of T12–L5 vertebrae, intervening intervertebral discs	Lesser trochanter of femur	Ventral rami of first four lumbar nerves	Acting superiorly with iliacus, flexes hip; acting inferiorly, flexes vertebral column laterally; used to balance trunk in sitting position; acting inferiorly with iliacus, flexes trunk	Lumbar branch of iliolumbar artery
Iliacus	Superior 2/3 iliac fossa, ala of sacrum, and anterior sacroiliac ligaments	Lesser trochanter of femur and shaft inferior to it, to psoas major tendon	Femoral nerve (L2–L4)	lexes thigh at hips and stabilizes hip joint, acts with psoas major	Iliac branches of iliolumbar artery
Quadratus lumborum	Medial half of inferior border of 12th rib, tips of lumbar transverse processes	Iliolumbar ligament, internal lip of iliac crest	Ventral rami of T12 and first four lumbar nerves	Extends and laterally flexes vertebral column, fixes 12th rib during inspiration	Iliolumbar artery
Diaphragm	Xiphoid process, lower six costal cartilages, L1–L3 vertebrae	Converge into central tendon	Phrenic nerve (C3–C5)	Draws central tendon down and forward during inspiration	Pericardiacophrenic musculophrenic, superior and inferior phrenic arteries

Arteries of Posterior Abdominal Wall (see Section 4.6, Abdomen—Visceral Vasculature)

- Abdominal aorta
  - Origin of most of arteries supplying posterior wall
  - Begins anterior to body of T12 and ends at bifurcation of common iliac arteries at L4
- Common iliac artery
  - Follows medial border of psoas
  - Divides into internal and external iliac arteries at pelvic brim
  - External iliac
    - Gives off inferior epigastric and deep circumflex arteries
    - Exits under inguinal ligament as the femoral artery
    - Supplies lower limb
  - Internal iliac artery supplies pelvis
- Unpaired visceral branches of abdominal aorta
  - Celiac trunk (T12)
  - Superior mesenteric (L1)
  - Inferior mesenteric (L3)
- Paired visceral branches
  - Suprarenal arteries (L1)
  - Renal arteries (L1)
  - Gonadal arteries (L2) (Note: gonadal arteries branch from anterior aorta.)
- Paired parietal branches
  - Subcostal arteries (T12)
  - Inferior phrenic arteries
  - Lumbar arteries (four pairs)
- Unpaired parietal branch: Median sacral artery arising just above aortic bifurcation

Veins of Posterior Abdominal Wall (see *Section 4.6, Abdomen—Visceral Vasculature*)

- Inferior vena cava (IVC)
  - Formed from union of common iliac veins
  - Begins anterior to body of L5 and passes through diaphragm at T8
  - Its tributaries follow branches of aorta
  - Exceptions
    - Left gonadal vein drains to left renal vein.
    - Left suprarenal vein drains to left renal vein.
  - Blood from abdominal viscera
    - Drains via portal system and liver
    - Reaches IVC through the hepatic veins
  - Ascending lumbar veins
    - Drain to azygos/hemi-azygos veins and then to superior vena cava (SVC)
    - Forms anastomosis between IVC and SVC.

Lymphatics of Posterior Abdominal Wall

- Common iliac nodes
  - Receive lymph from external and internal iliac nodes
  - Drain to lumbar (para-aortic) nodes
- Lumbar (para-aortic) nodes
  - Receive lymph from posterior abdominal wall, descending colon, kidneys, ureters, testes/ovaries, uterus, uterine tubes
  - Efferent vessels form lumbar lymphatic trunks
- Pre-aortic nodes
  - Receive lymph from digestive tract, liver, spleen, and pancreas
  - Efferent vessels form intestinal lymphatic trunks

Nerves of Posterior Abdominal Wall *(see Section 4.7, Abdomen—Innervation)*

- Somatic nerves
  - Subcostal nerves
    - Ventral primary rami of T12
    - Arise in thorax
    - Run inferiorly on surface of quadratus lumborum
    - Supply external abdominal oblique and skin of anterolateral abdominal wall
  - Lumbar nerves
    - Dorsal and ventral primary rami of lumbar spinal nerves
    - Dorsal rami supply muscles and skin of back
    - Ventral rami pass into substance of psoas major muscle and form lumbar plexus
- Nerves of lumbar plexus
  - Ilio-inguinal and iliohypogastric nerves (L1)
    - Enter abdomen posterior to medial arcuate ligament
    - Pierce transverse abdominis near anterior superior iliac spine (ASIS)
    - Supply skin of suprapubic and inguinal regions
  - Genitofemoral nerve (L1/2)
    - Emerges from anterior surface of psoas muscle
    - Runs inferiorly deep to fascia
    - Divides into genital and femoral branches
  - Lateral femoral cutaneous nerve (L2/3)
    - Emerges from lateral aspect of psoas muscle
    - Runs inferiorly on iliacus
    - Enters thigh posterior to inguinal ligament and medial to ASIS
  - Obturator nerve (L2–L4)
    - Emerges from medial border of psoas
    - Descends through pelvis to obturator canal
    - Supplies muscles and skin of medial thigh
  - Femoral nerve (L2–L4)
    - Emerges from lateral border of psoas
    - Innervates iliacus
    - Passes beneath inguinal ligament on surface of iliopsoas muscle
    - Innervates muscles of anterior thigh
  - Lumbosacral trunk (L4/5)
    - Descends over ala of sacrum into pelvis
    - Joins in formation of sacral plexus
- Autonomic nerves
  - Thoracic splanchnic nerves
    - Greater (T5–T9), lesser (T10–T11), and least (T12) thoracic splanchnic nerves
    - Convey presynaptic sympathetic fibers to celiac, superior mesenteric, and aorticorenal sympathetic ganglia
  - Lumbar splanchnic nerves
    - Rise of abdominal sympathetic trunks
    - Three or four in number
    - Convey presynaptic sympathetic fibers to inferior mesenteric, intermesenteric, and superior hypogastric plexuses

- Prevertebral sympathetic ganglia
  - Celiac
  - Superior mesenteric
  - Inferior mesenteric
  - Aorticorenal
- Parasympathetic fibers
  - Preganglionic
  - From anterior and posterior vagal trunks and pelvic splanchnic nerves
- Autonomic plexuses
  - Contain preganglionic sympathetic and parasympathetic fibers, postganglionic sympathetic fibers, sympathetic ganglia (prevertebral), and visceral afferent fibers
  - Some named for major blood vessels (periarterial): celiac, superior mesenteric, inferior mesenteric, intermesenteric, aorticorenal
  - Superior hypogastric plexus—continuous with inferior mesenteric and intermesenteric plexuses at aortic bifurcation

Internal Features of Anterior Abdominal Wall

- Lined by parietal peritoneum
- Five peritoneal folds, inferior to umbilicus
  - Median umbilical fold
    - Extends in midline from bladder to umbilicus
    - Represents remnant of urachus
  - Medial umbilical folds (two)
    - One on either side of median umbilical fold
    - Represent remnants of umbilical arteries
  - Lateral umbilical folds (two)
    - One on either lateral side of medial umbilical folds
    - Over inferior epigastric vessels
- Peritoneal fossae are formed between the umbilical folds.
  - Supravesical fossae: between median and medial folds
  - Medial inguinal fossae: between medial and lateral folds
  - Lateral inguinal fossae
    - Lateral to lateral folds
    - Site of deep inguinal ring (beneath peritoneum)
- Falciform ligament
  - Sharp-edged fold of peritoneum
  - Extends between peritoneum of abdominal wall above umbilicus and liver
  - Contains round ligament of the liver (ligamentum teres hepatis: remnant of the umbilical vein)

Hesselbach's (Inguinal) Triangle.

- Boundaries
  - Medial: lateral border of rectus abdominis
  - Lateral: inferior epigastric vessels
  - Inferior: inguinal ligament
- Significance
  - Only peritoneum, endoabdominal fascia, and transversalis fascia form wall
  - Superficial inguinal ring lies directly external to it
  - It is thus the site where direct inguinal hernias protrude from abdominal cavity.

Inguinal Canal: Feature of Anterior Abdominal Wall.

- Oblique canal, approximately 4 cm long at inferior margin of anterior abdominal wall
- Parallel and superior to medial half of inguinal ligament
- Deep inguinal ring: internal entrance to canal
  - Entrance to canal through transversalis fascia
  - Located 1.25 cm superior to midpoint of inguinal ligament
  - Occurs lateral to epigastric vessels
- Superficial ring: external exit of canal
  - Exits through external oblique aponeurosis
  - Located superolateral to pubic tubercle
- Boundaries
  - Anterior wall: external oblique aponeurosis (and internal oblique laterally)
  - Posterior wall
  - Transversalis fascia laterally
  - Internal oblique and conjoint tendon (joint insertion of aponeuroses of internal oblique and transverses abdominis) medially
  - Roof: arching fibers of internal oblique
  - Floor: inguinal ligament, reinforced medially by lacunar ligament
- Contents
  - Spermatic cord in men
  - Round ligament in women (*see Section 5, Pelvis and Perineum*)
  - Ilio-inguinal nerve
  - Blood and lymphatic vessels

CLINICAL POINTS

INGUINAL HERNIA

- Most abdominal hernias occur in inguinal region.
- Most hernias are inguinal hernias.
- Inguinal hernias are more common in men.
- About 20% are direct inguinal hernias.
- Direct inguinal hernias protrude through layers of wall in Hesselbach's (inguinal) triangle, *medial* to epigastric vessels.
- Hernial sac consists of peritoneum containing portion of viscus (usually small or large bowel).
- Indirect hernias that leave abdomen *lateral* to epigastric vessels, entering inguinal canal through its deep ring.
- The hernial sac consists of peritoneum containing a portion of a viscus (usually small or large bowel) and is covered by the layers covering the spermatic cord.
- The hernia may continue through the superficial ring and into the scrotum.

PSOAS ABSCESS

- Abscess is usually caused by the spread of lumbar vertebral tuberculosis to the psoas sheath.
- The sheath becomes thickened and pus accumulates beneath it.
- Pus tracks inferiorly within the sheath, deep to the inguinal ligament, surfacing in the superior part of the thigh.
- Should pus track to the adjacent iliac fascia, a recess may form—the iliacosubfascial fossa.
- The large bowel can become trapped in this fossa, with resulting severe pain.

MEMORY AIDS

Muscles of the abdominal wall: **TIRE**
Transversus abdominis
Internal oblique
Rectus abdominis
External oblique

4.3 PERITONEAL CAVITY

Study Aims

At the end of your study, you should be able to:

- Understand the difference between the abdominopelvic and peritoneal cavities
- Be able to explain the difference between the greater sac and the lesser sac (omental bursa)
- Understand the organization of the peritoneal folds that form the greater omentum, lesser omentum, the mesentery of the small intestine, and other mesenteries and peritoneal ligaments
- Know which organs are intraperitoneal, retroperitoneal, and secondarily retroperitoneal
- Describe the subdivisions of the peritoneal cavity

GUIDE

PERITONEUM

- Serous membrane
  - Lines abdominopelvic cavity
  - Consists of two continuous layers of mesothelium
    - Parietal peritoneum
      - Lines internal abdominal wall
      - Receives its neurovascular supply from region of wall it lines
    - Visceral peritoneum
      - Invests abdominal viscera
      - Receives its neurovascular supply from that of organ
- Peritoneal cavity
  - *Potential* space between parietal and visceral layers of peritoneum
  - Contains thin film of fluid
  - No organs actually lie within this potential space.
  - Males: peritoneal cavity is completely closed
  - Females: communicates with exterior of body via uterine tubes, uterus, and vagina
- Intraperitoneal organs
  - Organs nearly totally covered by visceral peritoneum
  - *Not* actually *inside* peritoneal cavity, but project into peritoneal cavity
  - Covered by peritoneum
  - Attached to body wall and other organs by mesenteries and ligaments
  - Include
    - Liver
    - Spleen
    - Stomach
    - First part of duodenum
    - Jejunum
    - Ileum
    - Transverse colon
    - Sigmoid colon
    - Superior rectum
- Primarily retroperitoneal organs
  - Organs that develop and remain beneath parietal peritoneum
  - Only kidneys
- Secondarily retroperitoneal organs
  - Organs that developed with short mesentery
  - Become pushed against parietal peritoneum lining body wall by growth of other organs, primarily small intestine
  - Mesentery of organ fuses with parietal peritoneum: fusion fascia
  - Peritoneum covers only its anterior surface, hence, secondarily retroperitoneal
  - Organ can be freed at its lateral edge, along plane of fusion fascia
  - Include
    - Adrenal glands
    - Pancreas
    - Parts two through four of duodenum
    - Ascending and descending colon

Omenta

- Omentum = double-layered fold of peritoneum
- Lesser omentum: connects lesser curve of stomach and proximal duodenum to liver
  - Passes from stomach and first part of duodenum to adjacent organs
  - Consists of two parts
    - Hepatogastric ligament
    - Hepatoduodenal ligament
- Greater omentum
  - Hangs down from greater curve of stomach and proximal duodenum
  - Folds back on itself to attach to transverse colon

Mesenteries

- Mesentery = double layer of peritoneum created by invagination of peritoneum by an organ
- Continuity of visceral and parietal peritoneum
- Provides pathway for neurovascular communication between organ and body wall
- Contains lymph nodes and variable amounts of fat
- *Mesentery* is mesentery of small intestine
- *Mesocolon* is mesentery of large intestine
  - Transverse mesocolon
  - Sigmoid mesocolon

Peritoneal Ligaments

- Ligament = double layer of peritoneum connecting an organ to another organ or to abdominal wall
- Ligaments of liver
  - Falciform ligament: from liver to anterior abdominal wall
  - Gastrohepatic ligament
    - From lesser curvature of stomach to liver
    - = Portion of lesser omentum

  - Hepatoduodenal ligament
    - From liver to first part of duodenum
    - = Right, thickened free edge of lesser omentum
    - Contains portal triad (portal vein, hepatic artery, bile duct)
- Ligaments of stomach
  - Gastrophrenic ligament: from stomach to inferior diaphragmatic surface
  - Gastrosplenic ligament: from stomach to hilum of spleen
  - Gastrocolic ligament: from stomach as greater omentum to transverse colon
- Ligaments of spleen
  - Gastrosplenic: from stomach to hilum of spleen
  - Splenorenal (lienorenal): from spleen to left kidney
- Phrenicocolic ligament (sustentaculum lienis)
  - From left hepatic flexure of transverse colon to diaphragm
  - Supports spleen

Peritoneal Subdivisions

- Greater sac: main peritoneal cavity
- Lesser sac (omental bursa)
  - Posterior to stomach
  - Visible through lesser omentum
  - Superior recess: limited by diaphragm and posterior layers of coronary ligament of liver *(see Section 4.4, Abdomen—Viscera [Gut])*
  - Inferior recess: potential space between layers of greater omentum
  - Communicates with greater sac via epiploic foramen (of Winslow)

Boundaries of Epiploic Foramen

Boundary	Structures
Anterior	Hepatoduodenal ligament containing portal triad
Posterior	Inferior vena cava (IVC) and right crus of diaphragm, which is covered by parietal peritoneum
Superior	Caudate lobe of liver, which is covered by visceral peritoneum
Inferior	First part of duodenum, portal vein, hepatic artery, bile duct

- Supracolic compartment
  - Greater sac above transverse mesocolon
  - Contains stomach, liver, and spleen
- Infracolic compartment
  - Greater sac below transverse mesocolon
  - Contains small bowel, ascending and descending colon
  - Divided into left and right divisions by mesentery of small intestine
  - Free communication between supracolic and infracolic compartments via paracolic gutter
    - Grooves or recesses between ascending and descending colon and posterior abdominal wall along their lateral borders

ANATOMICAL POINTS

The **greater omentum** is often referred to as the "abdominal policeman." It can move within the peritoneal cavity and wrap itself around an inflamed organ, localizing inflammation and preventing adhesion between the visceral peritoneum and parietal peritoneum of the abdominal wall.

There are several ways to access the omental bursa:

- Directly through the lesser omentum
- Through the transverse mesocolon
- Through the gastrocolic ligament (part of the greater omentum)

CLINICAL POINTS

PERITONITIS

- Inflammation of the peritoneum
- Can be localized (e.g., secondary to appendicitis) or generalized (e.g., secondary to bowel perforation)
- Can result in reflex tensing ("guarding") of the overlying abdominal musculature leading to abdominal rigidity
- Involvement of parietal peritoneum leads to well-localized, sharp abdominal pain with tenderness on palpation.

ASCITES

- Accumulation of fluid in the peritoneal cavity
- May form secondary to peritonitis or a variety of other pathological conditions
- Abdomen may become grossly distended as many liters of fluid accumulate.
- Paracentesis may be undertaken both for diagnostic purposes and for draining the ascitic fluid.
- Usually performed under local anesthesia

4.4 VISCERA (GUT)

Study Aims

At the end of your study, you should be able to:

- Describe the structure of the stomach and its neurovascular supply
- Describe the structure of the duodenum, its immediate anatomical relationships, and its neurovascular supply
- Understand the orientation of the small bowel within the abdomen and describe its divisions and neurovascular supply
- Understand the course of the large bowel within the abdomen and describe its divisions and neurovascular supply
- List distinguishing features of the jejunum, ileum, and large intestine

GUIDE

STOMACH

- J-shaped enlargement of gastrointestinal tract
- Chief function: enzymatic digestion
  - Acidic gastric secretions convert food into liquid *chime*
  - Passes fairly quickly into duodenum

- Parts of the stomach
  - Greater curvature: long, convex border
  - Lesser curvature: short, concave border
  - Cardia: surrounds cardial (esophageal) orifice
  - Fundus: dilated upper part
    - Above level of esophageal orifice
    - Dilated by fluid, food, but mainly gas
    - Separated from esophagus by cardiac notch
  - Body: between fundus and pyloric antrum
  - Pyloric part
    - Begins at level of angular incisure: indentation two thirds of way along lesser curvature
    - Widest region: pyloric antrum
    - Antrum leads to pyloric canal
    - Pylorus: surrounds pyloric orifice
    - Pyloric sphincter
    - Thick, circular middle layer of muscularis externa
    - Controls passage of chime into duodenum
    - Normally closed in tonic contraction, except during peristalsis
- Three muscle layers: outer longitudinal, inner circular, and innermost oblique
- Internal surface thrown into numerous longitudinal folds—rugae
  - Gastric canal = longitudinal fold along lesser curvature
  - Forms during swallowing
  - Accommodates passage of liquid
- Covered by peritoneum except where blood vessels run over it and over small area posterior to cardiac orifice
  - Double layer of peritoneum extends between stomach and liver and duodenum and liver: lesser omentum
  - Two layers of lesser omentum wrap around stomach and leave greater curvature as great omentum

Vascular Supply ***(see Section 4.6, Abdomen—Visceral Vasculature)***

- Arteries
  - Left gastric from celiac trunk
  - Right gastric from common hepatic artery
  - Right gastro-epiploic (gastro-omental) from proper hepatic or gastroduodenal arteries
  - Left gastro-epiploic from splenic artery
  - Short gastric arteries (four or five) from distal splenic artery
- Veins
  - Follow arteries
  - Right and left gastrics drain to portal vein
  - Short gastrics and left gastro-epiploic drain into splenic vein → superior mesenteric vein (SMV) → portal vein
  - Right gastro-epiploic drains to SMV
- Lymphatics
  - Follow arteries
  - Drain into gastric, gastro-epiploic, pancreaticosplenic, and pyloric nodes

Innervation (see Section 4.7, Abdomen—Innervation)

- Parasympathetic supply
  - From anterior and posterior vagal trunks
  - Increase peristalsis and relax pyloric sphincter
- Sympathetic supply
  - From T6–T9 spinal cord segments via great splanchnic nerve to celiac plexus
  - Inhibit peristalsis and contract pyloric sphincter

DUODENUM

- First and shortest part of small intestine
- Follows C-shaped course around head of pancreas
- Consists of four parts *(parts 2 through 4 are retroperitoneal)*
  - Superior (first) part: anterolateral to body of L1
    - Ascends from pylorus
    - Connected to liver by hepatoduodenal ligament (part of lesser omentum)
    - Portal vein, bile duct, and IVC located posteriorly
  - Descending (second) part
    - Descends along right of L1–L3
    - Contains major duodenal papilla on posteromedial wall = opening of hepatopancreatic ampulla
  - Horizontal (third) part
    - Crosses inferior vena cava (IVC), aorta, and L3 vertebra
    - Crossed by superior mesenteric artery (SMA) and SMV and root of mesentery
  - Ascending (fourth) part
    - Ascends to L2 on left side
    - Curves anteriorly at duodenojejunal flexure
    - Flexure is supported by ligament of Treitz

Vascular Supply ***(see Section 4.6, Abdomen—Visceral Vasculature)***

- Arteries
  - Gastroduodenal artery, branch of common hepatic → superior anterior and posterior pancreaticoduodenal arteries
  - SMA → anterior and posterior inferior pancreaticoduodenal arteries
  - Important anastomoses between celiac trunk and SMA via duodenal arteries
- Veins
  - Follow arteries
  - Drain directly or indirectly into portal vein
- Lymphatics
  - Follow arteries
  - Drain into pancreaticoduodenal, pyloric, superior mesenteric, and celiac lymph nodes

Innervation ***(see Section 4.7, Abdomen—Innervation)***

- Parasympathetic supply from vagus via celiac and superior mesenteric plexuses
- Sympathetic supply via celiac and superior mesenteric plexuses, traveling on pancreaticoduodenal arteries

JEJUNUM AND ILEUM

- Begins at duodenojejunal juncture and ends at ileocecal junction
- Together are approximately 6 M long

Mesentery

- Double-layered fold of peritoneum
- Attaches jejunum and ileum to posterior abdominal wall

- Root of mesentery
  - Follows oblique line
  - Runs inferiorly and to right, from ligament of Treitz to ileocolic junction
- Between two layers are SMA, SMV, lymph nodes, fat, and autonomic nerves

Jejunum

- Approximately two fifths of the length
- Mainly in left upper quadrant (LUQ)
- Thick walled and very vascular

Ileum

- Approximately three fifths of the length
- Mainly in right lower quadrant (RLQ)
- Thin walled and less vascular
- Terminates at ileocecal junction

Vascular Supply (*Section 4–6: Abdomen—Visceral Vasculature*)

- Arteries
  - Superior mesenteric artery
  - 15 to 18 branches from SMA to jejunum and ileum
  - Branches unite to form loops or arches (arterial arcades)
  - Arcades give rise to straight arteries = vasa recta
  - Double row of arcades to ileum
- Veins
  - SMV drains ileum and jejunum
  - Posterior to neck of pancreas joins splenic vein to form portal vein
- Lymphatics
  - Specialized lymphatic vessels that absorb fat = lacteals
  - Absorbed fat = chyle
  - Lacteals found in villi (fingerlike projections of intestinal mucosa)
  - Lacteals drain to lymphatic plexuses in walls of jejunum and ileum
  - Lymphatics pass between layers of mesentery to mesenteric lymph nodes and then to superior mesenteric or ileocolic nodes
  - Lymph drains to cisterna chyli

Innervation (*see Section 4.7, Innervation*)

- Parasympathetic supply
  - Preganglionic fibers from posterior vagal trunks
  - Synapse on postganglionic cells in myenteric and submucosal plexuses in intestinal wall
- Sympathetic supply
  - Preganglionic fibers from T5–T9 spinal cord segments → sympathetic trunks → greater and lesser splanchnic nerves
  - Synapse on postganglionic cells in celiac and superior mesenteric ganglia

LARGE INTESTINE (COLON)

- Characterized by
  - Teniae coli: 3 thickened longitudinal bands of muscle *(absent from appendix and rectum)*
  - Haustra: sacculations of colon caused by teniae coli
  - Appendices epiploicae: fatty lobules of omentum

Cecum

- Blind pouch, approximately 7.5 cm in diameter
- No mesentery but may be bound to abdominal wall by cecal folds of peritoneum
- Invaginated by ileum to form ileocecal valve—does not prevent reflux
- Vermiform appendix
  - Arises from posteromedial side of cecum
  - Usually retrocecal
  - Has short mesentery from cecum: meso-appendix
  - Supplied by appendicular artery from ileocolic artery
- Vascular supply: ileocolic artery and vein, with lymph to ileocolic nodes
- Nerves: sympathetic and parasympathetic nerves from superior mesenteric plexus
  - Parasympathetic fibers from vagus nerves
  - Sympathetic fibers from lower thoracic spinal cord segments

Ascending Colon

- On right side of posterior abdominal wall
- Extends from cecum to liver, where it turns at right colic flexure (hepatic flexure)
- Secondarily retroperitoneal
- Vascular supply from branches/tributaries of SMA/SMV
  - Ileocolic artery and vein
  - Right colic artery and vein
- Lymphatics to epicolic and paracolic nodes
- Nerve supply from the superior mesenteric plexus

Transverse Colon

- Extends from hepatic flexure on right to splenic flexure on left
- Largest and most mobile section of colon
- Attached to posterior abdominal wall by its mesentery: transverse mesocolon
- Vascular supply from branches/tributaries of SMA/SMV
  - Left colic artery and vein
  - Right colic artery and vein
  - Middle colic artery and vein
- Lymphatic drainage to middle colic nodes
- Nerve supply
  - Superior mesenteric plexus along right and middle colic arteries
  - Inferior mesenteric plexus along left colic arteries

Descending Colon

- Left side of posterior abdominal wall
- Extends from splenic flexure to sigmoid colon
- Secondarily retroperitoneal
- May have short mesentery in one third of people
- Vascular supply from branches/tributaries of IMA/IMV
  - Left colic artery and vein
  - Superior sigmoid artery and vein
- Lymphatic drainage to epicolic and paracolic nodes
- Innervation
  - Sympathetic fibers from lumbar sympathetic trunk and superior hypogastric plexus
  - Parasympathetic fibers from pelvic splanchnic nerves

Sigmoid Colon

- S-shaped loop of variable length
- Links descending colon with rectum
- Long mesentery with V-shaped root: sigmoid mesocolon
- Vascular supply from branches/tributaries of inferior mesenteric artery (IMA)/inferior mesenteric vein (IMV)
  - Left colic artery and vein
  - Superior sigmoid artery and vein
- Lymphatic drainage to epicolic and paracolic nodes
- Innervation
  - Sympathetic fibers from lumbar sympathetic trunk and superior hypogastric plexus
  - Parasympathetic fibers from pelvic splanchnic nerves

Rectum and Anal Canal *(see Section 5–9: Pelvis and Perineum—Rectum and Anal Canal)*

- Rectum
  - Begins anterior to body of S3 vertebra
  - Approximately 15 cm long
  - Connects sigmoid colon and anal canal
  - Fixed, and continuous with the anal canal
- Anal canal
  - Begins at distal end of rectal ampulla
  - Extends from pelvic diaphragm to anus

CLINICAL POINTS

HIATUS HERNIA

- Herniation of part of the stomach through the esophageal hiatus of the diaphragm
- May cause pain and discomfort and predispose to reflux of gastric contents
- Sliding hernias involve the cardia of the stomach sliding superiorly.
- Rolling hernias (less common) involve part of the fundus extending through the hiatus.

CONGENITAL HYPERTROPHIC PYLORIC STENOSIS

- Thickening of smooth muscle of the pylorus
- Causes severe stenosis of pyloric canal
- Gastric emptying is greatly reduced and typically leads to the presentation of projectile vomiting following a feeding.
- More common in males and usually presents 3 to 8 weeks after birth
- Diagnosis made by palpating a pyloric mass in the right upper quadrant (RUQ) during a test feeding

INTESTINAL VOLVULUS

- Rotation of loop of bowel on its mesentery
- May cause acute bowel obstruction
- Can compromise the vascular supply leading to ischemia, infarction, and eventually necrosis
- Most commonly occurs in the mobile small bowel, but may also affect the sigmoid colon, owing to the length of its mesentery
- Prompt surgical decompression may be required, although passage of a flatus tube is usually sufficient in cases of sigmoid volvulus.

MEMORY AIDS

Stomach Parts: "The CAR is FUN 'til the BODY PILES"
This relates to the four parts of the stomach:

Car	**C**ardiac
Fun	**F**undus
Body	**B**ody
Piles*	**P**ylorus

Bowel segments:	Dow Jones Industrial Average's Closing Stock Report
Dow	**D**uodenum
Jones	**J**ejunum
Industrial	**I**leum
Average's	**A**ppendix (attached to cecum)
Closing	**C**olon
Stock	**S**igmoid
Report	**R**ectum

Sphincters of the gastrointestinal tract:	APE OIL
A	**A**nal
P	**P**yloric
E	**E**sophageal (lower)
O	**O**ddi
I L	**I**leocecal

4.5 VISCERA (ACCESSORY ORGANS)

Study Aims

At the end of your study, you should be able to:

- Describe the structure of the liver, its relations, and neurovascular supply
- Describe the structure of the gallbladder and its neurovascular supply and understand the biliary system
- Describe the structure of the pancreas, its relations, and neurovascular supply
- Describe the structure of the spleen, its relations, and neurovascular supply

GUIDE

LIVER

Largest gland in the body (approximately 1.5 kg)

Surfaces

- Smooth diaphragmatic surface, covered by peritoneum except over bare area
- Reflection of peritoneum from diaphragm to liver forms coronary ligament
  - Has anterior and posterior layers
  - Where layers meet on right = right triangular ligament
  - Posterior layer is continuous with lesser omentum

*The pylorus is where the food **piles** waiting for the sphincter to open

- Left triangular ligament formed by falciform ligament and lesser omentum
- Visceral surface
  - Separated anteriorly from anterior and superior surfaces by sharp inferior border
  - Covered by peritoneum except at porta hepatis and bed of gallbladder
  - Related to: right side of anterior stomach
    - First part of duodenum
    - Gallbladder
    - Right colic flexure and transverse colon
    - Right kidney and suprarenal glands

Ligaments

- Falciform ligament
  - Peritoneal reflection from upper anterior abdominal wall from umbilicus to liver
  - Has ligamentum teres hepatis (round ligament) in free edge
- Ligamentum teres hepatis (round ligament of liver)
  - Fibrous remnant of umbilical vein
  - Extended from umbilicus to liver
- Ligamentum venosum
  - Remnant of ductus venosus
  - Extended in fetus between umbilical vein and inferior vena cava (IVC)

Recesses

- Subphrenic recess separates liver from diaphragm (split by falciform ligament)
- Hepatorenal recess
  - On right side
  - Separates liver anteriorly from kidney and suprarenal gland posteriorly

Lobes

- Left, right, caudate, quadrate
- Functional "left liver" includes left lobe, caudate, and quadrate lobes

Porta Hepatis

- Transverse fissure on visceral surface between caudate and quadrate lobes
- Provides entrance/exit for:
  - Portal vein
  - Hepatic artery
  - Hepatic nerve plexus
  - Hepatic ducts (left and right converge to form common hepatic duct)
  - Lymphatic vessels

Vascular Supply *(see **Section 4.6, Abdomen—Visceral Vasculature**)*

- Liver receives blood from
  - Portal vein (70%)
  - Hepatic artery (30%)
- Hepatic veins (3)
  - Formed by union of central veins
  - Drain directly into the IVC inferior to diaphragm
- Lymphatics
  - Drain mainly to the hepatic nodes at the porta hepatis
  - From hepatic nodes → celiac nodes → cisterna chyli

Innervation *(see **Section 4.7, Abdomen—Innervation**)*

- Derived from hepatic nerve plexus
- Accompanies branches of hepatic artery and portal vein
- Sympathetic fibers from celiac plexus
- Parasympathetic fibers from anterior and posterior vagal trunks
- Role unknown except for vasoconstriction

GALLBLADDER

- Lies in fossa at junction of right and left lobes of liver
- Connected to liver by fibrous capsule of liver
- Stores bile produced by the liver
- Parts
  - Fundus—located at tip of 9th costal cartilage
  - Body—also in contact with transverse colon and first part of duodenum
  - Neck
    - Has S-shaped bend to joint cystic duct
    - Mucosa thrown into spiral fold—*spiral valve*—to keep cystic duct open
  - Cystic duct connects to common hepatic duct to form common bile duct

Vascular Supply *(see **Section 4.6, Abdomen—Visceral Vasculature**)*

- Artery: cystic artery from right hepatic artery
- Cystic veins
  - Veins draining neck and biliary ducts empty into portal vein
  - Veins draining body and fundus drain directly into liver
- Lymph drains to hepatic nodes

Innervation *(see **Section 4.7, Abdomen—Innervation**)*

- Sympathetic from celiac plexus
- Parasympathetic from vagus
- Sensory from right phrenic

PANCREAS

- Lies retroperitoneally and transversely across posterior abdominal wall
- Digestive gland with exocrine and endocrine functions
  - Exocrine: secretion of digestive juices
  - Endocrine: secretion of insulin and glucagon
- Parts
  - Head
    - Encircled by C-shaped curve of duodenum
    - Overlies IVC, left and right renal veins, and right renal artery
    - Contains embedded bile duct
    - Projection from inferior part—*uncinate process*—that extends to left
  - Neck
    - Overlies superior mesenteric vessels
    - Adjacent to pylorus of stomach
    - Superior mesenteric vein (SMV) joins splenic vein to form portal vein posterior to neck
  - Body
    - Crosses body of L2 and aorta
    - Lies in floor of omental bursa
    - Related anteriorly to stomach

    - Is in contact posteriorly with aorta, superior mesenteric artery (SMA), left suprarenal gland, left kidney, and related vessels
  - Tail
    - Lies anterior to left kidney
    - Related to hilum of spleen and left colic flexure
- Main pancreatic duct
  - Begins in tail and runs toward head
  - Turns inferiorly to join common bile duct to form hepatopancreatic ampulla (of Vater)
    - Opens on major duodenal papilla in descending portion of duodenum
    - Surrounded by sphincter of Oddi—smooth muscle
- Accessory pancreatic duct
  - Opens at summit of minor duodenal papilla
  - Can connect with main pancreatic duct (60% of time)
  - Can be main duct for pancreatic secretions
  - Variation as result of type of fusion or lack of fusion of dorsal and ventral pancreatic ducts during embryonic development

Vascular Supply *(see **Section 4.6, Abdomen—Visceral Vasculature**)*

- Arteries
  - Mainly from branches of splenic artery
  - Also from gastroduodenal, superior mesenteric, superior, and inferior pancreaticoduodenal arteries
- Veins
  - Mainly drain to splenic vein
  - Also drain to SMV and then portal vein
- Lymph
  - Follow blood vessels
  - Mainly drain into the pancreaticosplenic nodes along splenic artery

Innervation *(see **Section 4.7, Abdomen—Innervation**)*

- From the vagus
- From thoracic splanchnic nerves
- Fibers from celiac and superior mesenteric plexuses pass along arteries

SPLEEN

- Largest lymphatic organ, very vascular
- Located in left upper quadrant (LUQ)
- Related posteriorly with ribs 9 to 11 (separated by diaphragm)
- Covered by peritoneum except at hilum
- Surrounded by thin capsule of fibroelastic connective tissue
- Relations
  - Anterior: stomach (gastrosplenic ligament)
  - Posterior: diaphragm
  - Inferior: splenic flexure of colon
  - Medial: left kidney (splenorenal ligament)
  - Tail of pancreas extends to hilum
- Ligamentous attachments
  - Gastrosplenic ligament to greater curvature of stomach
  - Splenorenal ligament to left kidney
  - Both ligaments attach to hilum
  - Spleen sits on phrenicocolic ligament (sustentaculum lienis)

Vascular Supply *(**Section 4–6: Abdomen—Visceral Vasculature**)*

- Artery: splenic artery
  - Twisted course from origin at celiac trunk
  - Divides into five or more branches that enter at hilum
  - Lack of anastomoses between branches results in two or three vascular segments with avascular planes between
- Vein: splenic vein
  - Formed from several tributaries at hilum
  - Runs to right behind body and tail of pancreas
  - Joins SMV to form portal vein
- Lymph: drains to the pancreaticosplenic nodes

Innervation *(see **Section 4.7, Abdomen—Innervation**)*

- Derived from celiac plexus
- Travels along branches of splenic artery
- Vasomotor function

ANATOMICAL POINTS

The porta hepatis is the cross bar of the "H" on the visceral surface of the liver. The right arm of the H is formed by the inferior vena cava and the gallbladder. The left arm is formed by the fissure for the ligamentum teres hepatis and the fissure for the ligamentum venosum.

CLINICAL POINTS

GALLSTONES (CHOLELITHIASIS)

- Stonelike deposits are commonly seen in the gallbladder.
- If they obstruct the cystic duct, they can cause pain in the right upper quadrant (RUQ), especially after consumption of a fatty meal.
- Pain typically comes and goes (biliary colic) and may be associated with nausea and vomiting.
- Secondary inflammation of the gallbladder leads to constant pain and is often the trigger to seeking medical attention.
- If the gallstones pass further down, they may obstruct the biliary system (causing jaundice) or the pancreatic duct (causing pancreatitis).

SPLENIC RUPTURE

- The spleen is the most commonly damaged abdominal organ, despite being protected by the ribcage.
- Trauma causing rib fracture or sudden increases in intra-abdominal pressure (such as being impaled against a steering wheel in a road traffic accident) may result in rupture of the spleen.
- Bleeding is typically profuse owing to its thin capsule and soft parenchyma.

SUBPHRENIC ABSCESS

- Subphrenic recess is a common site for pus to accumulate.
- Right-sided abscesses are more common owing to the incidence of perforation of an inflamed appendix.

- Pus usually tracks into the hepatorenal recess in the supine position and is best drained inferior to the 12th rib (avoiding puncture of the pleura).

MEMORY AIDS

Spleen: "1, 3, 5, 7, 9, 11"
It measures 1 x 3 x 5 inches, weighs 7 ounces and lies between ribs 9 and 11

4.6 VISCERAL VASCULATURE

Study Aims

At the end of your study, you should be able to

- Know the unpaired branches of the abdominal aorta
- Know the major branches of the celiac trunk, superior mesenteric artery, and inferior mesenteric artery
- Know the unpaired branches of the abdominal aorta and their distribution of blood
- Understand the two types of venous drainage from the abdomen
- Describe the formation of the hepatic portal vein from the splenic and superior mesenteric veins
- Know the tributaries of the splenic and superior mesenteric veins
- Describe the lymphatic drainage of the abdomen

GUIDE

ARTERIAL SUPPLY

Unpaired Branches of Abdominal Aorta *(see Section 4.2, Body Wall)*

Celiac Trunk.

- Arises at T12
- Supplies
  - Lower one third of esophagus
  - Stomach
  - First and second parts of duodenum
  - Pancreas
  - Spleen
  - Liver
  - Biliary system
- Branches
  - Left gastric artery
    - Supplies distal esophagus and lesser curvature of stomach
    - Anastomosis with right gastric artery
  - Common hepatic artery
    - Extends retroperitoneally to right to reach hepatoduodenal ligament
    - Divides into gastroduodenal and proper hepatic arteries
    - Gastroduodenal artery branches
      - Superior pancreaticoduodenal supplying head of pancreas and proximal duodenum
      - Right gastro-epiploic artery supplying right side of greater curvature of stomach
    - Proper hepatic branches
      - Right and left hepatic arteries to right and left lobes of liver
      - Right gastric artery to right portion of lesser curvature of stomach
      - Cystic artery *usually from the right hepatic artery* supplies gallbladder and cystic duct
  - Splenic artery
    - Supplies body of pancreas and spleen directly
    - Branches
      - Left gastro-epiploic: supplies left side of greater curvature of stomach, anastomoses with right gastro-epiploic
      - Short gastric arteries: supply fundus of stomach

Superior Mesenteric Artery (SMA).

- Arises at L1
- Supplies gut from second part of duodenum as far as distal one third of transverse colon
- Major branches
  - Inferior pancreaticoduodenal
    - Supplies duodenum (distal to entry of bile duct), pancreas, and spleen
    - Anastomosis with superior pancreaticoduodenal
  - Jejunal and ileal branches
    - Form anastomotic loops (arterial arcades); fewer large loops in jejunum
      Many shorter loops in ileum
    - Loops give off vasa recta (straight arteries); longer in jejunum, shorter in ileum
  - Ileocolic artery
    - Supplies caecum and some of the ascending colon
    - Supplies appendix via appendicular branch
  - Right colic artery: supplies ascending colon and proximal transverse colon
  - Middle colic artery: supplies proximal two thirds of transverse colon

Inferior Mesenteric Artery (IMA).

- Arises at L3
- Supplies distal one third of the transverse colon → proximal rectum
- Branches
  - Left colic artery: supplies distal transverse, descending and sigmoid colon
  - Superior sigmoid artery(ies): supplies sigmoid colon
  - Superior rectal artery (terminal branch of inferior mesenteric): supplies proximal rectum

Median Sacral Artery.

- Arises from posterior aspect of aorta just above bifurcation
- Descends to supply lower lumbar vertebrae, sacrum, and coccyx

Arterial Supply: Paired Branches of the Abdominal Aorta

Inferior Phrenic Arteries.

- First branches of abdominal aorta (or from celiac trunk)
- Supply inferior surface of diaphragm
- Give rise to six to eight superior suprarenal arteries on either side

Middle Suprarenal Arteries.
- One or more on either side
- Originate from aorta near origin of celiac trunk

Renal Arteries.
- Arise at level of L1/L2 intervertebral disc
- Right renal artery longer and passes posterior to inferior vena cava (IVC)
- Divide close to hilum into five segmental end arteries

Gonadal Arteries.
- Arise inferior to renal arteries but superior to inferior mesenteric
- May arise at different levels on either side
- Run anterior to ureters, cross origin of external iliac vessels in suspensory ligament of ovary and enter broad ligament
- Divide into ovarian and tubal branches to supply ovary and uterine tube
- Branches anastomose with correspondingly named branches of uterine artery

Lumbar Arteries.
- Usually four pairs
- Given off from posterior aspect of aorta
- Each gives off a dorsal branch
  - Supplies musculature of back
  - Gives off spinal branch to vertebral column and spinal roots
- Rest of artery supplies anterolateral abdominal wall

Common Iliac Arteries.
- Formed by bifurcation of aorta at level of iliac crest (slightly below level of umbilicus)
- Follow medial borders of psoas muscle to pelvic brim
- Bifurcate into internal and external iliac arteries at pelvic brim
- Supply pelvic viscera and lower limb

Venous Drainage *(see Section 4.2. Body Wall)*
- Veins draining abdominal viscera are tributaries of one of two venous systems
  - Inferior vena cava (IVC)
  - Portal vein
- No vein equivalent to celiac trunk or gastroduodenal vein
- Splenic vein and superior mesenteric vein unite to form portal vein
  - Tributaries of splenic vein
    - Inferior mesenteric vein and its tributaries (left colic, sigmoid, superior rectal)
    - Pancreatic veins
    - Left gastro-epiploic vein
    - Short gastric veins
  - Tributaries of the superior mesenteric vein
    - Inferior pancreaticoduodenal vein
    - Right gastro-epiploic vein
    - Right colic vein
    - Ileocolic vein
    - Jejunal veins
    - Ileal veins
  - Veins draining directly into portal vein
    - Cystic vein
    - Superior pancreaticoduodenal
    - Left and right gastric veins also may
- Tributaries of the IVC
  - Common iliac veins
  - Lumbar veins
    - Enter IVC in irregular pattern
    - Second lumbar vein may enter left renal vein
    - Anastomose with tributaries of epigastric veins
    - Connected to each other on either side by vertical anastomotic channel, ascending lumbar vein
    - Ascending lumbar veins connect with azygos vein on right and hemi-azygos vein on left
  - Right gonadal vein (left drains to left renal vein)
  - Right and left renal veins
  - Right suprarenal vein (left drains to left renal vein)
  - Right inferior phrenic vein (left drains to left renal vein)
  - Hepatic veins
    - Two or three in number
    - Empty into IVC just below diaphragm
  - Blood from hepatic portal vein constitutes approximately 70% of the liver's blood supply

Lymphatic Drainage *(see Section 4.2, Abdomen—Body Wall and Section; Section 4.4, Abdomen—Viscera [Gut]* and *Section 4.5, Abdomen—Viscera [Accessory Organs]* for specific organs)
- Lymphatics generally follow arteries
- Drain to local, then regional lymph nodes (lumbar, celiac, superior, and inferior mesenteric nodes)
- Main lymphatic ducts of abdomen from regional nodes
  - Intestinal lymphatic trunks (single or multiple)
  - Right and left lumbar lymphatic trunks
- Thoracic duct
  - Begins with union of main lymphatic ducts of abdomen, unless cisterna chili is present
  - Ascends into thoracic through aortic hiatus in diaphragm
- Cisterna chili
  - Thin-walled sac or dilation at union of main lymphatic ducts of abdomen
  - Drains to thoracic duct
  - If present, occurs at the level of L1/2
  - Not seen in all individuals
  - Can vary in size and shape

CLINICAL POINTS

PORTAL HYPERTENSION
- Raised venous pressure within the portal circulation
- Resistance to portal blood flow may occur due to intrahepatic obstruction (fibrosis of the liver from cirrhosis).
- Resistance also may occur as a result of posthepatic obstruction (such as heart failure or Budd-Chiari syndrome) or prehepatic obstruction.
- Clinical consequences are ascites in the abdomen, congestive splenomegaly, hepatic encephalopathy, and the enlargement of portocaval venous anastomoses

BUDD-CHIARI SYNDROME

- Caused by hepatic vein obstruction (e.g., thrombosis or tumors)
- Patients present with acute epigastric pain and shock.
- May also have insidious portal hypertension, ascites, jaundice, and cirrhosis
- Surgery may relieve the obstruction.
- Liver transplantation may be needed.

ABDOMINAL AORTIC ANEURYSM

- Localized enlargement of aorta as a result of congenital or acquired weakness of wall
- Pulsations can be detected left of midline.
- Common site is just above bifurcation of aorta to common iliac arteries.
- Unrecognized rupture of an aneurysm has 90% mortality rate.

4.7 INNERVATION

Study Aims

At the end of your study, you should be able to:

- Describe the parasympathetic contribution to the autonomic innervation of abdominal viscera
- Describe the sympathetic contribution to the autonomic innervation of abdominal viscera
- Understand the organization of the autonomic plexuses of the abdomen
- Describe the somatic innervation of the abdominal wall
- Know the branches of the lumbar plexus
- Understand the principle of referred pain and describe common patterns of pain referral from the abdominal viscera

GUIDE

AUTONOMIC NERVES

Parasympathetic Nerves

- Preganglionic fibers
  - Provided by vagus nerve and sacral splanchnic nerves
  - Synapse with postganglionic fibers in walls of relevant organs
- Vagus nerve (CN X)
  - Give rise to anterior and posterior vagal trunks in thorax
  - Trunks enter abdomen at the esophageal hiatus.
- Anterior trunk (mainly from left vagus)
  - Enters anterior to esophagus
  - Gives branches to anterior surface of stomach and to liver
- Posterior trunk (mainly from right vagus)
  - Enters posterior to esophagus
  - Gives branches to posterior surface of stomach and celiac plexus
  - Fibers pass inferiorly to root of superior mesenteric artery
- Fibers contribute to perivascular plexuses
  - Accompanying celiac and superior mesenteric artery and their branches
  - Extend as far as arterial supply (two thirds of way along transverse colon)
- Pelvic splanchnic nerves
  - From spinal cord levels S2–S4
  - Emerge through pelvic sacral foramina
  - Ascend from pelvis running in sigmoid mesocolon and peritoneum of posterior abdominal wall
  - Supply distal one third of transverse colon, descending colon, sigmoid colon, and superior rectum
- Postganglionic (postsynaptic) parasympathetic neurons found in enteric ganglia in wall of viscus

Sympathetic Nerves

- Right and left sympathetic trunks
  - Enter behind medial arcuate ligament of diaphragm
  - Descend along psoas major, with right trunk behind inferior vena cava (IVC)
  - Lie on anterolateral sides of lumbar vertebrae
  - Receive white rami communicantes from, and send gray rami communicantes to, ventral rami of L1–L3 spinal nerves
  - Postganglionic fibers in gray rami communicantes to corresponding ventral rami of spinal nerves distributed to body wall and lower limb
  - Give off three or four lumbar splanchnic nerves (presynaptic sympathetic fibers) medially to
    - Intermesenteric plexus
    - Inferior mesenteric plexus
    - Superior hypogastric plexus
  - Postsynaptic fibers from these plexuses innervate nearby target organs.
- Sympathetic (*para*vertebral) ganglia
  - Total of four abdominal sympathetic ganglia per trunk
- *Pre*vertebral sympathetic ganglia
  - Cell bodies of postsynaptic sympathetic neurons
  - Found in plexuses around roots of major branches of aorta

Aortic Plexuses

- Network of parasympathetic and sympathetic nerves
  - Parasympathetic mainly from posterior vagal trunk
  - Sympathetic fibers from thoracic and lumbar splanchnic nerves *(see Section 3, Thorax)*
- Contain prevertebral ganglia
- Include
  - Celiac plexus
  - Aorticorenal plexus
  - Renal plexus
  - Superior mesenteric plexus
  - Intermesenteric plexus
  - Inferior mesenteric plexus
- Perivascular plexuses derived from aortic plexuses
- Visceral afferent fibers
  - Carry pain information
  - Travel with sympathetic fibers back to spinal cord

Referred Pain

- Information carried by visceral afferent fibers
- Fibers travel back to T5–L2/3 spinal cord levels via thoracic and lumbar splanchnic nerves

- Clinical phenomenon of referred pain is visceral pain perceived as somatic pain over the dermatomes innervated by cutaneous nerves with fibers from those spinal cord levels:

Organ	Spinal Level	Area of Referred Pain
Stomach	T5–T9	Epigastric or left hypochondrium
Duodenum	T5–T8	Epigastric or right hypochondrium
Jejunum	T6–T10	Periumbilical
Ileum	T7–T10	Periumbilical
Caecum	T10–T11	Periumbilical or right lower quadrant
Appendix	T10–T11	Periumbilical, then to right iliac fossa
Ascending colon	T10–T12	Periumbilical or right lumbar
Sigmoid colon	L1–L2	Left lower quadrant
Spleen	T6–T8	Left hypochondrium
Liver and gallbladder	T6–T9	Epigastric, later to right hypochondrium
Pancreas	T7–T9	Inferior epigastrium
Kidney	T10–L1	Small of back, flank
Ureter	T11–L1	Loin to groin

SOMATIC NERVES

Thoracoabdominal Nerves

- Ventral primary rami of T7–T11
- Travel in neurovascular plane between internal oblique and transversus abdominis muscles
- Innervate anterolateral abdominal wall, including parietal peritoneum

Subcostal Nerves

- Ventral primary rami of T12
- Follow inferior border of 12th rib
- Enter abdomen behind lateral arcuate ligaments
- Cross quadratus lumborum muscles and pierce transversus abdominis muscles to enter neurovascular plane
- Innervate anterolateral abdominal wall *(including parietal peritoneum)*

Lumbar Plexus

- Iliohypogastric nerve (L1)
  - Divides into lateral and anterior cutaneous branches
  - Pierces internal and external oblique muscles
  - Supplies buttocks and suprapubic region
- Ilio-inguinal nerve (L1)
  - Travels in inguinal canal
  - Joins spermatic cord after piercing internal abdominal oblique (Note: does not enter inguinal canal through deep inguinal ring.)
  - Provides cutaneous branches to skin of inguinal region
- Genitofemoral nerve (L1,2)
  - Emerges from anterior surface of psoas major muscle
  - Genital branch enters deep inguinal ring to innervate the cremaster muscle
  - Femoral branch passes beneath inguinal ligament in vascular compartment to enter femoral triangle and provides cutaneous branches to anteromedial thigh
- Lateral femoral cutaneous nerve (L2,3)
  - Passes beneath or through inguinal ligament, medial to anterior superior iliac spine (ASIS)
  - Innervates anterolateral thigh
- Obturator nerve (L2–L4)
  - Emerges from medial border of psoas major muscle
  - Passes through pelvis
  - Exits via obturator canal
  - Supplies skin and adductor muscles of medial thigh
- Femoral nerve (L2–L4)
  - Emerges from lateral psoas major muscle
  - Innervates iliacus
  - Passes beneath inguinal ligament on surface of iliopsoas muscle in muscular compartment
  - Enters femoral triangle to innervate flexors of the hip/extensors of leg at knee and skin of anterior thigh, medial aspect of leg, and foot.
- Lumbosacral trunk (L4,5)
  - Enters pelvis passing over ala of sacrum
  - Contributes to formation of sacral plexus with ventral rami of S1–S4 spinal nerves

ANATOMICAL POINTS

AUTONOMIC INNERVATION OF THE ABDOMINAL VISCERA

- A perivascular plexus of nerves accompanying the arterial supply to each organ provides autonomic innervation to the abdominal viscera.
- Each plexus has sympathetic and parasympathetic input, both with motor and sensory divisions.
- Motor control governs glandular secretion, smooth muscle activity, and vascular tone.
- Afferent nerves mediate distension of organs and tension on mesenteries.

4.8 KIDNEYS AND SUPRARENAL GLANDS

Study Aims

At the end of your study, you should be able to:

- Describe the structure of the kidneys, their immediate anatomical relations, and neurovascular supply
- Understand the arrangement of perirenal fat, pararenal fat, and renal fascia
- Describe the course of the ureters, points of constriction along their path, and their neurovascular supply
- Describe the structure of the suprarenal glands and their neurovascular supply
- Know the products of the suprarenal cortex
- Understand the products of the medullary cells and the relationship of these cells to the sympathetic nervous system

GUIDE

KIDNEYS

- Bean-shaped retroperitoneal organs
- Remove excess water, salts, and products of protein metabolism
- Composed of 1 to 4 million nephrons
- Structural parts of a nephron
  - Renal corpuscle
  - Proximal convoluted tubule
  - Thin and thick limbs of loop of Henle
  - Distal convoluted tubule
  - Collecting ducts
- Returns nutrients and necessary salts and chemicals to blood
- Lie on posterior abdominal wall at level of T12–L3
- Left kidney lies higher than right because of right lobe of liver
- Anatomical relations
  - Superoposterior: diaphragm
  - Inferoposterior: quadratus lumborum
  - Anterior (right): liver (separated by hepatorenal recess), duodenum, and ascending colon
  - Anterior (left): stomach, spleen, pancreas, jejunum, and descending colon
- Medial margin (concave) = hilum
  - Renal artery enters
  - Renal vein (artery posterior to vein) and renal pelvis (posterior to vessels) exit
  - Entrance to space within kidney: renal sinus
- Anatomical structures of the kidney
  - Superior and inferior poles
  - Hilum
  - Renal sinus: expansion of proximal end of ureter
    - Divides into two to three major calices
    - Each major calyx divides into two or three minor calices
    - Each minor calyx encircles a renal papilla: apex of renal pyramid
  - Cortex
    - Outer layer of kidney
    - Contains glomerulus, renal corpuscle, proximal and distal convoluted tubules, and proximal collecting ducts
  - Medulla
    - Inner layer of kidney
    - Divided into 10 to 18 pyramidal blocks of tissue: medullary pyramids
    - Contains thick and thin limbs of loops of Henle, distal parts of proximal and distal convoluted tubules, distal collecting ducts
- Renal fascia
  - Separates, but encloses kidneys and suprarenal glands with surrounding perirenal fat
  - Continuous superiorly with fascia of diaphragm
  - Helps to hold kidney in relatively fixed position
- Perirenal fat
  - Continuous at hilum with fat in renal sinus
  - Surrounds kidney and suprarenal gland
  - Cushions and helps to hold kidney in relatively fixed position
- Pararenal fat
  - External to perirenal fat and renal fascia
  - Most obvious posteriorly
  - Cushions and helps to hold kidney in relatively fixed position

Vascular Supply

- Right and left renal arteries
  - Branches of aorta (at L1/2), with the right passing posterior to inferior vena cava (IVC)
  - Lie anterior to renal pelvis
  - Each artery divides into five segmental end arteries; four anterior segmental arteries and one posterior segmental artery
- Right and left renal veins
  - Anterior to renal arteries
  - Left passes anterior to aorta and posterior to descending superior mesenteric artery (SMA) = so-called nutcracker
- Lymphatics
  - Follow renal veins
  - Drain into lumbar (aortic) lymph nodes

Innervation *(see **Section 4.7, Abdomen—Innervation**)*

- From renal plexus
- Parasympathetic fibers from vagus nerve
- Sympathetic fibers from thoracic splanchnic nerves

URETERS

- Retroperitoneal, muscular ducts from renal pelvis to urinary bladder
- Constricted at three sites along course
  - Junction of ureter and renal pelvis
  - As they cross pelvic brim
  - In wall of urinary bladder
  - Potential sites of obstruction of urinary calculi

Vascular Supply

- Arteries are branches from
  - Renal arteries
  - Gonadal arteries
  - Aorta
  - Can divide into ascending and descending branches
  - Freely anastomose
- Veins drain into renal and gonadal veins
- Lymphatics
  - Join renal lymphatic vessels
  - Or pass directly to lumbar (aortic) and common iliac nodes

Innervation

- From renal, aortic, superior, and inferior hypogastric plexuses
- Visceral afferent fibers (pain) follow sympathetic fibers to T11–L2 spinal cord segments

SUPRARENAL (ADRENAL) GLANDS

- Endocrine glands concerned with metabolism
- Have different shapes
  - Triangular right gland
  - Semilunar left gland
- Located between upper pole of kidney and diaphragm

- Surrounded by perinephric fat, inside the renal fascia
- Anatomical relations
  - Right gland
    - Anterior to diaphragm
    - Contacts IVC and liver
  - Left gland related to spleen, stomach, and left crus of diaphragm
- Parts
  - Cortex and medulla
  - Have different embryologic origins and functions
- Cortex
  - Derived from mesoderm
  - Secretes
    - Glucocorticoids
    - Mineralocorticoids
    - Corticosteroids
  - Secretions affect kidneys to control sodium and water retention
- Medulla
  - Primarily nerve tissue filled with sinusoids and capillaries
  - Medullary cells derived from neural crest cells: chromaffin cells
  - Innervated by preganglionic (presynaptic) sympathetic neurons
    - Act as postganglionic (postsynaptic) neurons
    - Secrete adrenaline (epinephrine) and noradrenaline (norepinephrine)
  - Secretions lead to typical sympathetic response to traumatic stress
    - Increase heart rate and blood pressure (BP)
    - Dilate bronchioles

Vascular Supply

- Arteries
  - Superior suprarenal arteries (6–8) from inferior phrenic artery
  - Middle suprarenal artery(ies) from aorta
  - Inferior suprarenal artery(ies) from renal artery
- Veins
  - Drainage into single, large suprarenal vein
  - Drains into renal vein on left and the IVC on right
- Lymphatics
  - Arise from plexus deep to capsule of gland
  - Arise from plexus in medulla
  - Many vessels leave glands draining to lumbar nodes

Innervation

- From celiac plexus and thoracic splanchnic nerves
- Fibers are myelinated presynaptic fibers.
- Synapse on chromaffin cells

ANATOMICAL POINTS

VASCULAR SUPPLY TO THE KIDNEY

- Variation in the vascular supply to the kidney is fairly common.
- Embryologically, the kidneys develop in the pelvis and ascend to their abdominal position.
- In doing so, they acquire successively more superior vessels from the aorta and IVC, whereas inferior vessels degenerate.
- Failure of degeneration of any of these vessels may result either in branches to the poles of the kidney or in accessory vessels at the hilum.
- Furthermore, the renal arteries are not infrequently divided before their arrival at the hilum.

CLINICAL POINTS

NEPHROLITHIASIS (KIDNEY STONES)

- Renal caliculi (stones) may be found anywhere between the renal calices and urinary bladder
- A stone in the ureter can cause significant distension.
- This results in colicky pain radiating from loin to groin as ureteric contractions try to move the stone distally.
- In the past, an intravenous urogram (pyelogram) was the imaging tool used to determine a filling defect in the ureter.
- More recently, a computed tomography (CT) scan has become the tool of choice because patients may have an allergic response to the dye used in the urogram.
- Management is usually conservative (waiting for the stone to pass), but may be surgical or involve lithotripsy (sonic disruption of the stone).

RENAL CYSTS

- Cysts are a common finding in the kidney.
- They may be solitary or multiple.
- Solitary cysts are usually of no clinical consequence.
- Multiple cysts may cause gross distortion and enlargement of the kidneys, culminating in renal failure.
- Multiple cysts may be caused by adult polycystic kidney disease, because of an autosomal dominant gene.

5 Pelvis and Perineum Study Guide

5.1 TOPOGRAPHIC ANATOMY

Study Aims

At the end of your study, you should be able to:

- Know the functions of the bony pelvis and pelvic girdle
- Identify prominent landmarks and their clinical relevance

GUIDE

FUNCTIONS OF THE PELVIC GIRDLE

- Site of attachment of axial skeleton and lower limbs
- Transmits weight of upper limbs, head, neck, and trunk to lower limb
- Involved in balance
- Protects and contains pelvic viscera (distal ureters, bladder, rectum, sigmoid colon, reproductive organs)

KEY LANDMARKS

- Anterior superior iliac spine (ASIS)
  - Site of lateral attachment of inguinal ligament
  - Site of attachment of sartorius and tensor fascia lata muscles
- Pubic tubercle
  - Medial point of attachment of inguinal ligament
- Pubic symphysis
  - Secondary cartilaginous joint
  - Location of T12 dermatome along its superior margin
- Midpoint between pubic tubercle and ASIS marks the site for palpating femoral artery and vein (the midinguinal point)
- Iliac crest
  - Follows curve between anterior posterior superior iliac spines
  - Highest point is at approximately level of umbilicus—level of L4 vertebral body
  - Supracristal plane passes between highest points of iliac crests
- Intergluteal or natal cleft
  - The cleft between the buttocks
  - Site of pilonidal sinus and abscess formation

CLINICAL POINTS

PREGNANCY

In pregnancy the placenta can be palpated above the pubic symphysis at 12 weeks, at the umbilicus at 12 weeks, and at the xiphisternum at 40 weeks.

ACUTE URINARY RETENTION

The bladder, if distended, may be palpated and percussed up to the umbilicus. On examination, the bladder is dull to percussion and in acute urinary retention, the patient may also complain of tenderness on palpation in the suprapubic region.

SUPRACRISTAL LINE

The supracristal line is useful landmark when performing a lumbar puncture because it corresponds to the 4th lumbar vertebral body. Lumbar puncture in adults is performed in the lateral decubitus position in the L4–L5 interspace.

PILONIDAL SINUS

The pilonidal sinus is a blind-ending hair-filled tract most commonly found in the midline of the natal cleft overlying the lower sacrum and coccyx and occurs in 26/1000 persons in the United States. The sinus can become infected, creating a so-called **pilonidal abscess** that usually requires drainage and/or excision of the sinus.

5.2 BONES AND LIGAMENTS

Study Aims

At the end of your study, you should be able to:

- Identify the components of the bony pelvis
- Define the boundaries of the pelvic cavity
- Describe the joints of the pelvis
- Describe the ligaments that strengthen the pelvis
- Outline the key differences between the male and female pelvis
- List the structures that pass through the greater and lesser sciatic foramina

GUIDE

BONES AND BOUNDARIES OF THE PELVIS

Bony Pelvis

- Strong ring
- Supports weight of body
- Provides attachment for powerful muscles that move lower limb
- Composed of four bones
  - Two hip bones, or innominate bones
  - Sacrum—five fused sacral vertebrae
  - Coccyx—four (+1) fused coccygeal vertebrae
- Hip, or innominate, bones each formed from
  - Ilium
  - Ischium
  - Pubis
  - Fuse at puberty
  - United by cartilage at acetabulum
- Pelvic girdle
  - Formed of hip bones and sacrum
  - Transmits weight from upper body to lower limbs

Pelvic Walls

- Formed by bones of bony pelvis, ligaments, muscle, and fascia
- Surround pelvic cavity

Pelvic Cavity

- Basin shaped
- Surrounded by bony pelvis
- Boundaries
  - Superior—pelvic inlet and inferior abdominal cavity
  - Inferior—pelvic diaphragm
  - Anterior wall—bodies and rami of pubic bone and pubic symphysis
  - Posterior wall—sacrum and coccyx, adjacent ilia, and overlying piriformis muscle
  - Lateral walls—hip bones, obturator foramen and membrane, and overlying obturator internus muscle

Pelvic Inlet, Outlet, and Brim

- Inlet defined by oblique plane
  - Extends from promontory to superior aspect of pubic symphysis
  - Lies at angle approximately 55 degrees from horizontal
- Rim of pelvic inlet = pelvic brim, composed of a bony line running through
  - Sacral promontory
  - Arcuate line of ilium
  - Pectineal line of pubis (pecten pubis)
  - Pubic crest
  - Superior edge of pubic symphysis
- Pelvic outlet is bounded by
  - Tip of coccyx
  - Sacrotuberous ligaments
  - Inferior ischiopubic rami and ischial tuberosities
  - Inferior edge of pubic symphysis
- Pelvic inlet divides pelvis into two parts
  - True pelvis, or lesser pelvis or pelvis minor
    - Lies between pelvic inlet and outlet
    - Contains pelvic viscera
  - False pelvis, or greater pelvis or pelvis major
    - Lies above pelvic brim
    - Between iliac fossae
    - Contains part of ileum and sigmoid colon
- Birth canal includes pelvic inlet, true pelvis, cervix, vagina, and pelvic outlet

JOINTS OF THE PELVIS

Lumbosacral Joints

- Composed of
  - Intervertebral joint via intervertebral disc between L4 and S1
  - Two posterior zygapophysial joints
- Reinforced by iliolumbar ligaments

Sacro-iliac Joint

- Articulation between ear-shaped surfaces of sacrum and ilium
- Atypical synovial joint formed with fibrocartilage rather than hyaline cartilage
- Movement is very limited.
- Stabilized by interosseous and anterior and posterior sacro-iliac ligaments

Pubic Symphysis

- Union of bodies of right and left pubic bones
- Secondary cartilaginous joint
- Fibrocartilaginous interpubic disc in joint
- Stabilized by superior and inferior pubic ligaments
- Affected by the hormone relaxin during pregnancy to permit freer movement between vertebral column and to increase pelvic diameter during childbirth

Sacrococcygeal Joint

- Articulation between sacrum and coccyx
- Secondary cartilaginous joint
- Stabilized by anterior and posterior sacrococcygeal ligaments

LIGAMENTS OF THE PELVIS

- The weight of the body acting through the spine will tend to rotate the sacrum, tipping the lower part backward.
- This movement is prevented by the sacrospinous and sacrotuberous ligaments.
  - Sacrospinous ligament: extends from lateral border sacrum to ischial spine
  - Sacrotuberous ligament: larger and extends from dorsum and lateral border sacrum and posterior surface ilium to ischial tuberosity
- Attachments of sacrospinous and sacrotuberous ligaments enclose the lesser and greater sciatic notches, respectively, forming the greater and lesser foramina

Structures Passing Through the Greater and Lesser Sciatic Foramina

Greater Sciatic Foramen	Lesser Sciatic Foramen
Piriformis muscle	Tendon of obturator internus
Sciatic nerve	Nerve to obturator internus
Inferior gluteal nerve and artery	Pudendal nerve
Internal pudendal nerve, artery, and vein	Internal pudendal artery
Nerve to obturator internus muscle	
Nerve to quadratus femoris	
Posterior cutaneous nerve of the thigh	

SEX DIFFERENCES OF PELVIS

- Differences linked to function
  - Pregnancy and childbirth in females
  - Heavier build and larger muscles of men
- Main differences
  - Pelvis is heavier and has more pronounced muscle attachment sites in men than in women.
  - Pubic arch is narrower and subpubic angle more acute in men than women.
  - Ischial tuberosities are closer in men than in women, and pelvis outlet is thus comparatively smaller.
  - All of the ilia are less flared in men than in women, so the greater pelvis is deeper.
  - Pelvic inlet is heart-shaped in men and more transversely oval in women.
  - Obturator foramen is round in men and oval in women.
  - Female pelvis is broader than in men to allow passage of fetal head.

ANATOMICAL POINTS

MEASUREMENTS OF THE PELVIC INLET

- Used to determine capacity of female pelvis for childbearing
- True conjugate diameter
  - Measured radiologically on a lateral x-ray
  - Distance from superior border of pubic symphysis to sacral promontory
- Transverse diameter: widest distance of pelvic inlet
- Oblique diameter: distance from sacro-iliac joint to contralateral iliopectineal line

CLINICAL POINTS

FRACTURES OF THE PELVIS

- A large force is required to fracture the pelvis, and fractures usually result from direct trauma, such as occurs in automobile accidents.
- The bony pelvis may fracture at any point and there may be associated damage to pelvic viscera; for example, bladder and urethral rupture can occur with fractures involving the pubis.
- Pelvic fractures are classified as stable or unstable.
  - In a stable fracture, the pelvis remains stable and there is only one break-point in the pelvic ring with minimal hemorrhage.
  - In an unstable fracture, the pelvis is unstable with two or more break-points in the pelvic ring with moderate to severe hemorrhage.
- Signs of a fractured pelvis include pain in the groin, hip, or lower back; difficulty walking; urethral, vaginal, or rectal bleeding; scrotal hematoma; and shock as a result of concealed hemorrhage (contained bleeding into the pelvic cavity)
- A fracture can be confirmed on radiograph and is seen as a break in continuity of the pelvic ring.

DECUBITUS ULCERS

- Also called pressure sores
- Can be a partial- or full-thickness loss of skin, underlying connective tissue, and can extend into muscle, bone, tendons, and joint capsules
- Two thirds of pressure sores occur in patients older than 70 years.
- Results from prolonged pressure on an area of skin, connective tissue, and muscle from a mattress, wheelchair seat, or bed rail
- Commonly occur in those with poor mobility, bed-bound, poor nutrition, and incontinence.
- Can become infected with bacteria from poor skin care or fecal or urinary incontinence
- The hip and buttock regions account for 67% of all pressure sores, with ischial tuberosity, trochanteric, and sacral locations being most common.
- In the sitting position, the ischial tuberosity bears the weight of the whole body and thus is a prime site of ulceration.

5.3 PELVIC FLOOR AND CONTENTS

Study Aims

At the end of your study, you should be able to:

- State the structures that form the pelvic floor
- Describe the two main muscles that form the pelvic floor and their attachments
- List the functions of the pelvic floor muscles
- Describe the attachments of the peritoneum within the pelvis and the location of the vesico-uterine and recto-uterine pouches in females and rectovesical pouch in males
- Understand the organization and function of the pelvic fascia
- Describe the clinical problems that may arise with weaknesses of the pelvic floor muscles

GUIDE

PELVIC FLOOR

- Formed by pelvic diaphragm
- Funnel-shaped
- Muscular partition from pubis to coccyx and from lateral wall to lateral wall
- Separates pelvic cavity from perineum inferiorly
- Transmits urethra, vagina (in females), and anal canal

MUSCLES OF PELVIC FLOOR

- Pelvic diaphragm is composed of two paired muscles
  - Levator ani
  - Coccygeus
- Levator ani muscle
  - Paired muscle
  - Principal muscle of pelvic floor
  - Supports pelvic contents
  - Actively maintains position of pelvic viscera
- Arcus tendineus: thickened line of fascia over obturator internus muscles running in arching line from pubis to ischial spine
- Central perineal tendon or perineal body
  - Fibromuscular body extending from perineum into urogenital hiatus
  - Site of numerous muscle attachments in the perineum
- Components of levator ani muscle
  - Pubococcygeus
    - Is anterior part of levator ani
    - Main contributor to levator ani
    - Arises from posterior body of pubic bone and anterior part of arcus
  - Tendineus
    - Runs posteriorly to attach to anococcygeal ligament and coccyx
  - Iliococcygeus
    - Posterior part of levator ani
    - Thin and poorly developed
    - Arises from posterior part of arcus tendineus and ischial spine
    - Attaches to anococcygeal raphe and coccyx
  - Puborectalis
    - Thickened band of muscle best seen inferior to pubococcygeus
    - Unites with its partner to make U-shaped sling around rectum at its junction with anus
    - Has sphincterlike action by pulling anorectal junction forward and contributing to anal continence
- Medial muscle fibers of the pubococcygeus border the urogenital hiatus
  - Most anterior fibers insert into urethra
  - Other fibers sweep behind vagina or prostate and insert into central perineal tendon—called *levator prostatae, or pubovaginalis.*
- Coccygeus muscle
  - Reinforces pelvic floor posteriorly
  - Arises from ischial spine
  - Inserts on lower two sacral and upper two coccygeal segments
  - Blends with sacrospinous ligament on its external surface
- Innervation of levator ani and coccygeus muscles
  - Levator ani innervated by branches from anterior rami of S3–S4 spinal nerves.
  - Puborectalis also innervated by branch of pudendal nerve (S2,3,4).
  - Coccygeus supplied by branches of anterior rami of S4–S5 spinal nerves.
- Functions of levator ani
  - Acting together, raise pelvic floor to increase abdominal pressure, such as when coughing, sneezing, urinating, defecating, lifting heavy objects
  - Important in voluntary control of micturition (urinating)
  - Supports pelvic viscera
  - Supports head of fetus

MUSCLES LINING LATERAL WALLS OF PELVIS

- Obturator internus muscle
  - Proximal attachment: pelvic surfaces of ischium and ilium and obturator membrane
  - Distal attachment: greater trochanter of femur
  - Innervated by nerve to obturator internus (L5, S1–S2)
  - Lateral rotator of thigh
- Piriformis muscle
  - Proximal attachment: pelvic surfaces of S2-4 segments of sacrum, sacrotuberous ligament
  - Distal attachment: greater trochanter of femur
  - Innervated by ventral rami of S1–S2 spinal nerves
  - Lateral rotator of this

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Obturator internus	Pelvic surface of obturator membrane and surrounding bone	Medial surface of greater trochanter of femur	Nerve of obturator internus	Laterally rotates extended thigh, abducts flexed thigh at hip	Internal pudendal and obturator arteries
Piriformis	Anterior surface of sacral segments 2–4, sacrotuberous ligament	Superior border of greater trochanter of femur	Ventral rami of upper L5, S1, S2	Laterally rotates extended thigh, abducts flexed thigh at hip	Superior and inferior gluteal arteries, internal pudendal artery
Levator ani	Body of pubis, tendinous arch of obturator fascia, and ischial spine	Perineal body, coccyx, anococcygeal raphe, walls of prostate or vagina, rectum, anal canal	Ventral rami of lower sacral nerves, perineal nerve	Supports pelvic viscera; raises pelvic floor	Inferior gluteal artery, internal pudendal artery and its branches (inferior rectal and perineal arteries)
Coccygeus (ischiococcygeus)	Ischial spine, sacrospinous ligament	Inferior sacrum, coccyx	Ventral rami of lower sacral nerves	Supports pelvic viscera, draws coccyx forward	Inferior gluteal artery

PELVIC FASCIA

- Occupies space between peritoneum and muscles of pelvic floor and walls
- Parietal pelvic fascia lines internal surface (facing pelvic cavity) of muscles of floor and walls.
- Visceral pelvic fascia invests each of the pelvic organs.
- Visceral and parietal fascia are continuous where organs penetrate pelvic floor.
  - Where they are continuous, fascia thickens to form tendineus arch of pelvic fascia (arcus tendinous fasciae pelvis).
  - Arches are bilateral bands running from pubis to sacrum, adjacent to viscera.
- Puboprostatic ligament
- Pubovesical ligament
- Sacrogenital ligaments
- Between parietal and visceral fascia is endopelvic fascia
  - Matrix or filler material
  - In certain areas, condenses and becomes more fibrous to form fascial "ligaments," or septa
- Major condensation is hypogastric sheath.
  - Runs from lateral pelvic wall to pelvic viscera
  - Separates retropubic space from presacral space
  - Serves as a conduit for vessels and nerves
- Transverse cervical (cardinal) ligaments are part of hypogastric sheath.
  - Run from lateral wall to uterine cervix and vagina
  - Uppermost part is beneath broad ligament and transmit uterine artery
  - Sufficiently fibrous to provide passive support for uterus
- Uterosacral (female) or genitosacral (male) ligaments
- Septa separate the pelvic organs and include
  - Vesicovaginal septum
  - Rectovesical septum
  - Rectovaginal septum
- Weakness of pelvic floor muscles or in pelvic fascia, which support the pelvic organs, can result in prolapse of pelvic organs (e.g., vaginal or rectal prolapse).

PELVIC CONTENTS

- Female pelvic viscera and perineum
  - Section 5.4: Urinary Bladder
  - Section 5.5: Uterus, Vagina, and Supporting Structures
  - Section 5.9: Rectum
- Male pelvic viscera and perineum
  - Section 5.4: Urinary Bladder
  - Section 5.8: Testis, Epididymis, and Ductus Deferens
  - Section 5.9: Rectum

CLINICAL POINTS

PERITONEAL REFLECTIONS

- Pelvic peritoneum
  - Lines lateral and posterior pelvic walls and pelvic floor
  - Covers rectum, urinary bladder, uterus, and adnexa in females
  - Covers anterior and lateral surfaces of upper portion of rectum in both sexes
- In men
  - Sweeps forward from rectum to bladder
  - Creates recess between rectum and bladder: *rectovesical pouch*
  - Continues over superior surface of bladder and ascends on internal side of anterior abdominal wall
- In women
  - Sweeps forward from rectum onto posterior fornix of uterus and posterior uterine wall
  - Creates recess between rectum and uterus: recto-uterine pouch (of Douglas)
  - Covers posterior, superior, and anterior surfaces of uterus before reflecting onto superior surface of bladder
  - Ascends on internal side of anterior abdominal wall
- Fluid (blood, pus) can collect in rectovesical or recto-uterine pouches, causing infection and forming pelvic abscesses.

5.4 URINARY BLADDER

Study Aims

At the end of your study, you should be able to:

- Describe the course of the pelvic ureters
- Outline the gross structure of the bladder
- Describe the relations of the bladder
- Describe the structure of the male urethra
- Describe the structure of the female urethra

GUIDE

URETERS

- Cross pelvic brim at level of sacro-iliac joint, anterior to bifurcation of common iliac artery to pierce posterior surface of bladder
- Enter posterolateral surface of bladder and run obliquely through bladder wall, creating flap valve
- In males: pass under ductus deferens, superior to seminal vesicles
- In women: descend posterior to ovary and into base of broad ligament, passing under uterine artery ("water under the bridge")
- Supplied by branches of common and internal iliac arteries and uterine artery (inferior vesicle artery in males) and drained by veins with same names.
- Innervated by fibers from adjacent autonomic plexuses

URINARY BLADDER

General Structure

- Lies posterior to pubic bones and pubic symphysis
- When empty is tetrahedron in shape and lies entirely within true pelvic cavity; spherical when full and may reach as high as umbilicus
- When empty has base (posterior surface) and one superior and two inferolateral surfaces

- Base (posterior surface) of bladder defined internally by two ureteric openings at superolateral corners and internal urethral opening inferiorly
- Triangular area defined by these openings is *vesicle trigone.*
- Ridge between two urethral openings is *interureteric fold.*
- Neck of bladder is where base and inferolateral sides meet, inferiorly.
- Anterior angle or apex is site of attachment of urachus—fibrous remnant of fetal allantois, which is seen as median umbilical ligament on anterior abdominal wall.
- Bladder wall is composed of thick layer of interwoven bundles of smooth muscle running transversely, longitudinally, and obliquely—detrusor muscle.
- In region of neck, detrusor muscle runs circularly as involuntary internal sphincter.
- Bladder mucosa is thrown into rugae except within trigone, which is smooth.

Relations of the Urinary Bladder

Border	Structure
Superior	Peritoneum
	Ileum
	Sigmoid colon
Inferolateral	Obturator internus muscle
	Levator ani muscle
	Obturator nerve
	Obturator artery and vein
	Superior vesical artery and vein
Anterior	Retropubic space—containing adipose tissue and veins
	Pubic crest
Posterior—male	Seminal vesicles
	Ampulla of ductus deferens
	Rectovesical pouch
	Ampulla of rectum
Posterosuperior—female	Vesico-uterine pouch
	Body of uterus
Posterior—female	Cervix
	Anterior wall vagina
Inferior—male	Prostate
	Prostatic venous plexus

Arterial Supply

- Superior vesicle arteries (branches of internal iliac artery) supply apex and superior part of bladder.
- Inferior vesical arteries supply fundus and neck in males.
- Vaginal arteries (branches of uterine arteries) supply fundus and neck in females.
- Obturator arteries (branches of internal iliac artery) provide arterial twigs.

Venous Drainage

- Vesical venous plexus drains to internal iliac plexus via inferior vesical veins.
- Communicates with prostatic venous plexus in males and uterovaginal venous plexus in females

Female Urethra

- 3- to 4-cm long fibromuscular tube bound to anterior vaginal wall
- Extends from internal urethral meatus of bladder to external meatus situated just anterior to vaginal opening in vestibule
- Descends with vagina through urogenital hiatus and pelvic diaphragm and through perineal membrane, where it is surrounded by external sphincter urethrae
- Para-urethral glands, homologs to the prostate, open on either side near external urethral orifice
- Supplied by internal pudendal and vaginal arteries
- Drained by veins of same name
- Innervated by branches of pudendal nerve via S2–S4 spinal cord segments and afferents run with pelvic splanchnic

Male Urethra

- 25-cm fibromuscular tube
- Conveys both urine and semen
- Extends from internal urethral meatus of bladder to external urethral meatus in glans penis
- Divided into three parts: prostatic, membranous, and spongy urethra

Comparison of Prostatic, Membranous, and Spongy Parts of the Male Urethra

	Prostatic Urethra	Membranous Urethra	Spongy Urethra
Length	3 cm	2 cm	15 cm
Extent	Internal urethral meatus to apex of prostate	Apex of prostate to perineal membrane	Bulb of penis to glans penis
Key anatomical features	Urethral crest (midline ridge) Prostatic sinuses (site of opening prostatic ducts) Prostatic utricle (blind-ending sac on urethral crest; remnant of fetal duct forming uterus in females) Ejaculatory duct (opens either side of the utricle)	Surrounded by striated muscle of external urethral sphincter Bulbo-urethral glands lie posterolaterally Pubic symphysis lies anteriorly attaching via pubourethral ligaments	
Blood supply	Inferior vesical and rectal arteries	Inferior vesical and rectal arteries	Internal pudendal artery via dorsal arteries of penis
Venous drainage	Veins of same names and prostatic venous plexus	Veins of same names and prostatic venous plexus	Prostatic venous plexus and internal pudendal veins
Nerve supply	Pudendal nerve (S2–S4) and prostatic plexus	Pudendal nerve (S2–S4) and prostatic plexus	Pudendal nerve (S2–S4) and prostatic plexus

CLINICAL POINTS

MICTURITION

- The bladder has a capacity of 400 to 500 mL.
- During micturition, coordinated reflexive contraction of detrusor and relaxation of external urethral sphincter occur.
- Controlled by autonomic and visceral innervation
  - Visceral afferent fibers traveling along tract of parasympathetic fibers are stimulated by stretching (and pain in lower bladder).
  - Parasympathetic innervation via pelvic splanchnic nerves and pelvic plexus reflexively stimulates detrusor contraction during micturition.
  - Sympathetic fibers via hypogastric plexus to bladder neck relax bladder neck (internal urethral sphincter) and prevent retrograde ejaculation during micturition in males.

FRACTURES OF PELVIS AND BLADDER INJURY

- The bladder lies immediately posterior to the pubic symphysis, and fractures of the pubis can be complicated by rupture of the bladder.
- The rupture can result in the extravasation of urine intraperitoneally if the peritoneum is torn.

URINARY TRACT INFECTIONS (UTIS)

- As a result of a shorter urethra, women are more susceptible to UTIs.
- Commonly occurs in women after sexual intercourse
- Pathogen is commonly *Escherichia coli*.
- Infection may lead to urethritis, cystitis, or pyelonephritis (inflammation of urethra, bladder, and kidneys, respectively).
- Symptoms include dysuria, urgency, frequency, and occasionally hematuria.

URINARY STRESS INCONTINENCE

- Factors maintaining continence in the female are the external urethral sphincter (striated muscle surrounding middle third of urethra) and support of the bladder and urethra by the levator ani muscles.
- Urinary stress incontinence is an involuntary loss of urine that occurs during coughing, sneezing, laughing, lifting, or exercise, because of the inability of these muscles to counter the increase in intra-abdominal pressure.
- Urinary stress incontinence is often seen in women who have had multiple pregnancies and vaginal childbirths and in men after prostate surgery.
- About 50% of all women have occasional urinary incontinence

MEMORY AIDS

"Water under the bridge"—denotes relationship of ureter **(water)** to uterine artery, as it passes under the artery.

5.5 UTERUS, VAGINA, AND SUPPORTING STRUCTURES

Study Aims

At the end of your study, you should be able to:

- Describe the anatomy of the uterus and its supporting ligaments
- Know the anatomy of the ovary and the uterine tubes in relation to the pelvic cavity, the peritoneum, and the uterus
- Know the anatomy of the cervix
- Understand the orientation of the cervix relative to the position of the uterus and changes with childbirth
- Understand the anatomy of the vagina

GUIDE

STRUCTURES

Uterus

Basic Structure.

- Pear-shaped organ
- Approximately 8 cm long by 5 cm wide
- Supported by the pelvic diaphragm
- Composed of
  - Body (corpus)—upper two thirds
  - Fundus—rounded upper part superior to entrances of uterine tubes
  - Isthmus—narrower area just above cervix
  - Cervix (neck)—cylindrical inferior part that projects into superior vagina
- Uterine cavity is small (6 cm in length) and slitlike.
- Uterine horns are superolateral regions where the uterine (fallopian tubes) enter.
- Uterine wall has three layers.
  - Perimetrium—outer layer of peritoneum with underlying connective tissue
  - Myometrium—middle, thick layer of smooth muscle
  - Endometrium—vascular inner mucosal layer the thickness of which varies with menstrual cycle and age
- Uterus has two surfaces: anteroinferior and posterosuperior.
- A portion of the cervix and body and fundus of uterus are covered with peritoneum.
- Cervix
  - Thick-walled canal, 2.5 cm long, connecting body of uterus with vagina
  - Communicates superiorly via internal os with uterus
  - Communicates with vagina inferiorly via external os
  - Approximately half of cervix lies above vagina (supravaginal) and is covered posteriorly with peritoneum of recto-uterine pouch.
  - Bladder is separated from anterior surface the supravaginal part of cervix by connective tissue.
  - Lower half of cervix (vaginal part) protrudes into vagina and can be examined clinically.

Relationships of the Uterus.

- **Lateral:** Broad ligament, transverse cervical (cardinal ligaments), ureters

- **Anterior**: Vesico-uterine pouch, superior surface of bladder
- **Posterior**: Recto-uterine pouch and anterior surface of rectum, loops of intestine in pouch

Vascular Supply of Uterus (Including Cervix).
- Arterial
  - Uterine arteries (branches of internal iliac arteries)
  - Vaginal arteries (branches of uterine arteries with anastomoses with internal pudendal arteries)
- Venous drainage: via uterine venous plexus to internal iliac veins
- Lymphatics drain to
  - External iliac nodes
  - Internal iliac and sacral nodes
  - Superficial inguinal nodes (along round ligament)

Innervation.
- From uterovaginal plexus, subdivision of inferior hypogastric (pelvic) plexus
- Sympathetic, parasympathetic, and visceral afferents to and from uterus pass through this plexus.
- Sympathetic innervation from lower lumbar spinal cord segments via lumbar splanchnic nerves and intermediate plexuses
- Parasympathetic innervation from pelvic splanchnic nerves (S2,3,4 spinal cord levels) via pelvic plexus
- Afferent fibers with pain information from body and fundus ascend through plexuses to lumbar splanchnic nerves to reach upper lumber/lower thoracic spinal cord segments.
- Afferent fibers with pain information from cervix and all information except for pain from body and fundus follow parasympathetic fibers back to central nervous system.

Variations in Position of the Uterus.
- When the bladder is empty, body of uterus is bent anteriorly on the cervix: anteflexion.
- Axis of cervix also bent forward relative to axis of vagina: anteversion.
- Thus the body of uterus lies on superior surface bladder.
- Full bladder reduces these angles.
- Reversal of these angles is called *retroversion* and *retroflexion*.

Vagina

Basic Structure.
- Muscular tube, 8 to 10 cm long
- Superior end surrounds cervix; upper two thirds lie within pelvic cavity.
- Slopes downward and forward through pelvic diaphragm
- Opens inferiorly into vestibule between labia minora
- Lining has multiple transverse folds—*rugae*
- Recessed area of vagina around cervix is called *vaginal fornix*; composed of shallow anterior, deep posterior, and lateral fornices.
- Posterior fornix directly related to recto-uterine pouch

Relationships of the Vagina.
- Superior: external os cervix
- Inferior: vestibule between labia minora
- Anterior: posterior wall bladder
- Posterior: recto-uterine pouch, ampulla of rectum
- Lateral: levator ani muscles

Blood Supply.
- Uterine arteries supplies superior part
- Vaginal arteries supply middle part
- Lower part supplied by middle rectal and internal pudendal arteries

Venous Drainage.
- Vaginal venous plexus to uterine venous plexus to internal iliac veins

Innervation.
- Upper three fourths same as uterus
- Lower one fourth is somatic via pudendal nerve.
- Visceral and sympathetic fibers reach lower one fourth via pudendal nerve; no parasympathetics.

Ligaments Associated with the Uterus

Broad Ligament.
- Double layer of peritoneum that sweeps up and over uterus, ovaries, and uterine tubes
  - Thus has anterior and posterior lamina
  - Extends from sides of uterus to lateral pelvic walls
  - Part that suspends ovary from posterior lamina is the *mesovarium*.
  - Part of broad ligament above level of ovary and mesovarium that sweeps over uterine tubes is the *mesosalpinx*.
  - Part of broad ligament below mesovarium is mesentery of uterus.
- Uterine arteries and veins run medially from internal iliac arteries to uterus at its base.
- Encloses plexus of uterine veins

Ligament of the Ovary.
- Extends from medial pole of ovary to lateral wall of uterus, just at entrance of uterine tube, on each side
- Remnant of proximal part of embryonic gubernaculums

Round Ligament of the Uterus.
- Extends from lateral wall of uterus, just beneath entrance of uterine tube, to lateral pelvic wall on each side
- Crosses external iliac vessel to enter deep inguinal ring
- Passes through inguinal canal to labium majus
- Remnant of distal part of embryonic gubernaculums

Suspensory Ligament of the Ovary.
- Extension of broad ligament superiorly on posterolateral pelvic wall
- Covers ovarian vessels, associated nerves, and lymphatics

Uterine (Fallopian) Tubes

Basic Anatomy.
- Approximately 10 cm long, extending laterally from uterine horns to peritoneal cavity near ovaries
- Run in free upper border of broad ligament (mesosalpinx)
- Provide channel for ova from ovary to uterine cavity and site for fertilization

- Divided into four parts for descriptive and functional purposes
  - Infundibulum
    - Horn-shaped distal end
    - Opens into peritoneal cavity
    - Fingerlike processes (fimbriae) at distal end that spread over surface of ovary
  - Ampulla
    - Widest and longest part
    - Where fertilization usually occurs
    - Connects infundibulum and isthmus
  - Isthmus
    - Thick-walled
    - Enters uterine horn
  - Uterine part: passes through wall of uterus

Blood Supply.
- Arterial (anastomoses)
  - Uterine arteries
  - Ovarian arteries
- Venous drainage
  - Uterine venous plexus
  - Ovarian veins

Lymphatics.
- To lumbar lymph nodes

Innervation.
- Ovarian and uterine plexuses = subdivisions of pelvic plexus

Ovaries

Basic Structure.
- Ovoid in shape
- Approximately 4 cm long by 2 cm wide
- Lie in ovarian fossa on lateral pelvic wall between external and internal iliac vessels
- Attached to broad ligament by mesovarium, which transmits ovarian vessels
- Connected to lateral wall by suspensory ligaments of the ovary, containing ovarian vessels, nerves, and lymphatics

Arterial Supply.
- Ovarian artery
  - Branch of abdominal aorta
  - Terminates in ovarian and tubal branches

Venous Drainage.
- Pampiniform plexus combines to form single ovarian vein
- On right, drains into inferior vena cava
- On left, drains into left renal vein

Lymphatics.
- Follow ovarian vessels to lumbar lymph nodes

Innervation.
- Sympathetic and afferent fibers reach ovary via ovarian vessels.
- Parasympathetic fibers from pelvic splanchnic nerves (S2,3,4 spinal cord levels) reach ovary via same route.

CLINICAL POINTS

- The thickness of the endometrium (vascular mucosal lining) changes throughout the menstrual cycle, undergoing thickening and shedding.
- Following menopause the uterus and vagina undergo atrophy.
- Because the upper two thirds of the vagina lie within the pelvic cavity, weakness of the pelvic floor muscles can lead to vaginal prolapse.
- The lumen of fallopian tubes communicates with the peritoneal cavity at its distal (ovarian) end.
- The ovary is covered only by a thin layer of mesothelium, an extension of the mesovarium, to permit ovulation of the mature ovum into the peritoneal cavity.
- Ectopic pregnancies are therefore possible within the peritoneum.
- Fertilization of an ovum usually occurs within the fallopian tubes at the ampulla (the widest part).
- Ectopic pregnancies—implantation of a blastocyst other than in the uterine wall—can occur in the uterine tube (tubal pregnancy—most common ectopic pregnancy), into the ovary (ovarian pregnancy—rare) or into the abdominal wall (peritoneal pregnancy—very rare)
- Blockage of the uterine tubes as the result of disease is a common cause of infertility.

CERVICAL CANCER

- Common between age 40 and 60 years
- Was the leading cause of death of women in the United States until 1940, when detection of malignancies and premalignant conditions was made possible by the development of Pap (Papanicolaou) smears.
- Risk factors include early sexual activity, multiple sexual partners, human papillomavirus infection, and smoking.
- 85% to 90% are squamous cell carcinomas; 10% to 15% are adenocarcinomas.

FIBROIDS

- Benign tumors of smooth muscle cells of uterine myometrium
- Occur in 30% all women
- Can occur in any location within the uterus
- Growth stimulated by estrogen and oral contraceptive pill
- Symptoms usually a result of compression effects

5.6 PERINEUM AND EXTERNAL GENITALIA: FEMALE

Study Aims

At the end of your study, you should be able to:

- Outline the general organization of the perineum
- Describe the contents of the urogenital and anal triangles
- Describe the central perineal tendon and perineal membrane
- Outline the fascial layers and spaces of the perineum
- Describe the anatomy of the clitoris, labia, and vestibule
- Outline the blood supply of the external genitalia
- Outline the innervation of the female external genitalia

GUIDE

PERINEUM

General Organization (Same as Male)

- Narrow region between superior medial aspects of thigh
- With lower limbs abducted in lithotomy position, becomes a diamond-shaped area
- Bounded by pelvic diaphragm superiorly and superficial fascia and skin inferiorly
- Anal canal, urethra, and vagina pass through the perineum
- Boundaries:
  - Anterior: pubic symphysis
  - Posterior: inferior sacrum and coccyx
  - Anterolateral: ischiopubic rami
  - Lateral: ischial tuberosities
  - Posterolateral: sacrotuberous ligaments
- Divided into two triangles by imaginary line between ischial tuberosities
- Posteriorly is anal triangle
- Anteriorly is urogenital triangle

Contents of the Anal Triangle (Same as Male)

- Anal canal and anus
- External and internal anal sphincters
- Ischiorectal fossa

Contents of Urogenital Triangle

- Membranous and distal urethra
- Vagina
- Vulva (labia majora, labia minora, and clitoris)
- Erectile bodies of vulva

Central Perineal Tendon (Perineal Body) (Same as Male)

- Located at midpoint of the line dividing the urogenital from anal triangles
- Mass of collagenous and elastic fibers
- Deep to skin
- Anterior to anal canal
- Posterior to bulb of the penis (male) or vestibule (female)
- Site of attachment for
  - Bulbospongiosus
  - Superficial transverse perineal muscles
  - Deep transverse perineal muscles
  - External anal sphincter
  - Fascicles of muscle from external sphincter urethrae and levator ani

Perineal Membrane

- Everything same as male, except
- Sphincter urethrae (external urethral sphincter)
  - May exist in females
  - Some fibers extending to the ischiopubic rami (compressor urethrae) and some encircling the vagina as well
- Pierced by vagina and urethra

Fascia and Spaces of the Urogenital Triangle

- Everything same as male, except
- Superficial perineal space (pouch)
  - Between membranous layer of superficial fascia and perineal membrane
  - Contains:
    - Crura of clitoris and associated muscles
    - Bulbs of vestibule and associated muscles
    - Superficial transverse perineal muscles
    - Branches of internal pudendal vessels and pudendal nerves
    - Greater vestibular glands
- Deep perineal space (pouch)
  - Lies between perineal membrane and pelvic diaphragm
  - Ischio-anal fossae extend anteriorly into this space
  - Contains:
    - Proximal part of urethra
    - External sphincter urethrae muscle
    - Deep transverse perineal muscles
    - Vessels and nerves

FEMALE EXTERNAL GENITALIA

Anatomical Features

- Female external genitalia collectively called the vulva
- Female external genitalia include
  - Mons pubis
  - Labia majora
  - Labia minora
  - Clitoris
  - Vestibule of vagina
  - Bulbs of vestibule
  - Greater vestibular glands
- Mons pubis
  - Fatty tissue lying anterior to pubic symphysis and superior pubic rami
  - Skin continuous with anterior abdominal wall
  - After puberty is covered with pubic hair
- Labia majora
  - Longitudinal folds of skin containing fat, smooth muscle, and termination of round ligament of uterus
  - Lie on either side of pudendal cleft
  - Externally contain sebaceous glands and are covered by pubic hair
  - Internally are smooth and hairless
  - Unite anteriorly as the anterior commissure
  - Form a posterior commissure posteriorly, which disappears after childbirth
- Labia minora
  - Longitudinal folds of hairless skin without fat enclosed by labia majora
  - Surrounds vestibule of vagina
  - Extend from clitoris around urethra and vagina
  - Meet anteriorly as a small fold = frenulum of the clitoris, which passes deep to the clitoris
  - Posteriorly unite as frenulum (fourchette)
- Vestibule
  - Region enclosed by labia minora
  - Contains external urethral meatus, vaginal introitus (most inferior opening) and opening of ducts of paraurethral gland
  - Contains opening of ducts of greater vestibular (Bartholin's) glands

  One gland on either side of vestibule

  Posterior to vaginal orifice

  Ductal openings either side of vagina; secrete mucus during sexual arousal

- Contains bulbs of vestibule

Elongated masses of erectile tissue
One on either side of vaginal introitus
Homologous to bulb of penis and corpus spongiosum

- Clitoris
  - Resembles inverted "V"
  - Composed of root and body, located where labia minora meet anteriorly
  - Lies 2 cm anterior to external urethral meatus
  - Body composed of two crura, two corpora cavernosa, and glans clitoris
  - Highly innervated, becomes engorged during sexual arousal
  - Prepuce of clitoris—anterior extension of labia minora

Vascular Supply and Innervation

Arterial Supply.

- External pudendal arteries (branches of femoral artery)
- Internal pudendal arteries
  - Labial and clitoral branches of internal pudendal artery

Venous Drainage.

- Internal pudendal vein
- Venae comitantes of internal pudendal artery

Lymphatic Drainage.

- To superficial inguinal nodes

Innervation.

- Anterior labial nerves from ilio-inguinal nerve
- Perineal branch from posterior femoral cutaneous nerve
- Posterior labial nerves from pudendal nerve

CLINICAL POINTS

BARTHOLIN CYST

- Cystic swelling of greater vestibular (Bartholin's) glands
- Occurs when gland is infected or duct is blocked
- Can enlarge to 4 to 5 cm

CARCINOMA OF THE VULVA

- Mimics chronic ulcer
- Patient presents with pain, a discharging ulcer and occasionally a lump
- Metastasis is to inguinal lymph nodes
- Greater vestibular gland is origin of most vulvular adenocarcinomas

CHILDBIRTH AND THE PERINEAL BODY

- Overt or occult tearing of perineal body results in permanent weakness of pelvic floor
- Can involve tearing of posterior vaginal wall and overlying skin
- Slow to heal because of lack of vascular supply
- Episiotomy done if tearing of perineum is predicted
- Incision usually made from posterior vaginal wall through midline to just anterior to anus

5.7 PERINEUM AND EXTERNAL GENITALIA: MALE

Study Aims

At the end of your study, you should be able to:

- Outline the general organization of the perineum
- Describe the contents of the urogenital and anal triangles
- Describe the central perineal tendon and perineal membrane
- Outline the fascial layers and spaces of the perineum
- Describe the anatomy of the scrotum
- Describe the anatomy of the penis

GUIDE

PERINEUM

General Organization (Same as Female)

- Narrow region between superior medial aspects of thigh
- With lower limbs abducted in lithotomy position, becomes a diamond-shaped area
- Bounded by pelvic diaphragm superiorly and superficial fascia and skin inferiorly
- Anal canal, urethra, and vagina (females) pass through the perineum
- Boundaries
  - Anterior: pubic symphysis
  - Posterior: inferior sacrum and coccyx
  - Anterolateral: ischiopubic rami
  - Lateral: ischial tuberosities
  - Posterolateral: sacrotuberous ligaments
- Divided into two triangles by imaginary line between ischial tuberosities
- Posteriorly is anal triangle
- Anteriorly is urogenital triangle

Contents of Anal Triangle (Same as Female)

- Anal canal and anus
- External and internal anal sphincters
- Ischiorectal fossa

Contents of Urogenital Triangle

- Membranous and spongy urethra (males); distal urethra (females)
- Vagina (females)
- Proximal erectile bodies of the penis (males) and vulva (females)
- Attachment of scrotum

Central Perineal Tendon (Perineal Body) (Same as Female)

- Located at midpoint of line dividing urogenital from anal triangles
- Mass of collagenous and elastic fibers
- Deep to skin
- Anterior to anal canal
- Posterior to bulb of penis (male) or vestibule (female)

- Site of attachment for
  - Bulbospongiosus
  - Superficial transverse perineal muscles
  - Deep transverse perineal muscles
  - External anal sphincter
  - Fascicles of muscle from external sphincter urethrae and levator ani

Perineal Membrane

- Thin sheet of deep fascia
- Runs between two ischiopubic rami
- Spans anterior pelvic outlet
- Pierced by urethra and ducts of bulbo-urethral glands
- Attached to perineal body at midpoint of posterior margin
- Thickened anterior margin = transverse perineal ligament
- Superficial transverse perineal muscles
  - Lie superficial to (external to) perineal membrane
  - Extend from ischiopubic ramus on either side along posterior aspect of perineal membrane to attach to perineal body
- Deep transverse perineal muscles
  - Lie deep to (internal to) perineal membrane
  - Extend from ischiopubic ramus on either side along posterior aspect of perineal membrane to attach to perineal body
- Sphincter urethrae (external urethral sphincter)
  - Lies deep to (internal or superior to) perineal membrane
  - Circular fibers around membranous part of urethra in males
  - Anterior to deep transverse perineal muscles
- Deep transverse perineal muscles and sphincter urethrae traditionally termed *urogenital diaphragm*

Fascia and Spaces of Urogenital Triangle

- Superficial fascia of urogenital triangle has two layers, similar to the abdomen
  - Superficial fatty layer
  - Deep membranous layer (Colles' fascia)
  - Superficial layer replaced in penis and scrotum by dartos layer (smooth or dartos muscle)
- Membranous layer of superficial fascia
  - Posteriorly attached to posterior margin of perineal membrane and perineal body
  - Laterally attached to deep fascia (fascia lata) of superior medial thigh
  - Anteriorly is continuous with membranous layer of superficial fascia of abdomen (Scarpa's fascia)
- Deep perineal fascia (Gallaudet's fascia)
  - Invests ischiocavernosus, bulbospongiosus, and superficial transverse perineal muscles
  - Fused to suspensory ligament of penis or clitoris
- Superficial perineal space (pouch)
  - Between membranous layer of superficial fascia and perineal membrane
  - Contains in males
    - Bulb and crura of penis and associated muscles
    - Proximal spongy urethra
    - Superficial transverse perineal muscles
    - Branches of internal pudendal vessels and pudendal nerves
  - Contains in females
    - Crura of clitoris and associated muscles
    - Bulbs of vestibule and associated muscles
    - Superficial transverse perineal muscles
    - Branches of internal pudendal vessels and pudendal nerves
    - Greater vestibular glands
- Deep perineal space (pouch)
  - Lies between perineal membrane and pelvic diaphragm
  - Ischio-anal fossae extend anteriorly into this space.
  - Contains
    - Membranous urethra
    - External sphincter urethrae
    - Bulbo-urethral glands: secrete clear mucus during sexual excitation; ducts descend through perineal membrane and terminate in spongy urethra
    - Deep transverse perineal muscles
    - Vessels and nerves

MALE EXTERNAL GENITALIA

Scrotum

- Sac derived from skin and superficial fascia of abdominal wall.
- Contains testes, epididymis, and distal portion spermatic cord
- Skin shows midline scrotal raphe = fusion of bilateral labioscrotal swellings in embryo
- Dartos fascia
  - Continuation of deep membranous layer of superficial fascia of abdomen
  - Contains significant smooth muscle = dartos muscle
  - Extends inward, forming scrotal septum, separating right and left halves
- Deep to dartos, tunics of spermatic cord (external spermatic, cremasteric, and internal spermatic fascia) form a fused layer around and external to tunica vaginalis.
- Supplied by external pudendal arteries and veins
- Lymphatics drain to superficial inguinal lymph nodes.
- Innervated by
  - Anterior: ilio-inguinal nerve and genital branch of genitofemoral
  - Posterior: posterior scrotal nerves (terminal branches of the pudendal) and perineal branches of posterior femoral cutaneous nerves

Penis

- Male organ of copulation
- Composed of a *body* (shaft), *root,* and *glans*
- *Body* is
  - Anchored in superficial perineal space (pouch) and attached to perineal membrane
  - Contains three cylindrical masses of erectile tissue
    - Paired corpora cavernosa in parallel on dorsal surface
    - Corpus spongiosum in midline of urethral surface (facing scrotum)
  - Each erectile body covered by a fibrous tunic albuginea
- Corpora cavernosa
  - Diverge posteriorly to form crura of penis
  - Each crus attaches to inferior surface of corresponding ischiopubic ramus, anterior to ischial tuberosity.

- *Glans* of the penis is distal expansion of corpus spongiosum: proximally it forms bulb.
- Membranous urethra pierces the perineal membrane and enters the bulb from above (then called *spongy urethra*) and terminates at external urethral meatus (at apex glans).
- *Root* of penis is formed by bulb and crura.
- Two muscles are associated with erectile bodies.
  - Bulbospongiosus muscle
  - Ischiocavernosus muscle
- Body is surrounded by deep fascia (Buck's fascia), external to tunic albuginea.
- Skin of penis is connected to deep fascia by loose areolar connective tissue.
- At neck of the glans, the skin and connective tissue of penis extend and create double-layered fold—*prepuce*, or *foreskin*
- Vessels and nerves run on dorsum of penis.
  - Between skin and deep fascia
  - Between deep fascia and tunica albuginea

Innervation.
- Dorsal nerve of the penis from the pudendal nerve
  - Passes length of penis lateral to dorsal artery on that side
  - Lies beneath deep fascia
  - Supplies skin and glans
- Ilio-inguinal nerve supplies skin of proximal shaft of penis.
- Erection controlled by parasympathetic nerves (pelvic splanchnic nerves), which relaxes smooth muscle in coiled arteries of penis supplying erectile bodies

Arterial Supply.
- Dorsal arteries of penis from internal pudendal arteries run on either side of deep dorsal vein beneath deep fascia.
- Deep arteries from internal pudendal arteries
  - Run distally within center of corpora cavernosa
  - Highly coiled branches (helicine arteries) supply erectile tissue.
- Artery of bulb of penis from internal pudendal artery supplies posterior corpus spongiosum.
- External pudendal arteries supply skin of penis (branch of femoral artery).

Venous Drainage.
- Deep dorsal vein of penis receives blood from venous plexus
  - Drains to prostatic venous plexus and then to internal iliac/internal pudendal veins
- Superficial dorsal vein of penis drains to superficial external pudendal vein.

Lymphatic drainage mainly to superficial inguinal nodes

Muscles of the Penis

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Bulbospongiosus	Median raphe, bulb of penis and perineal body	Perineal membrane, corpus cavernosum and bulb of penis	Deep branch of perineal nerve from pudendal nerve	Compresses bulb of penis, forces blood into body of penis during erection, removes urine from urethra and semen during ejaculation	Internal pudendal artery and its branch (perineal artery)
Ischiocavernosus	Inferior internal surface of ischiopubic ramus, ischial tuberosity	Crus of penis	Deep branch of perineal nerve from pudendal nerve	Forces blood into body of penis during erection Compresses outflow veins	Internal pudendal artery and its branch (perineal artery)

CLINICAL POINTS

- Urethral rupture may occur spontaneously or occur as a result of external (fractures of the pelvis, penetrating injury) or internal (following catheterization or instrumentation) trauma.
- Site of urethral rupture determines where urine will extravasate.
- The superficial perineal fascia is continuous with the deep membranous layer of the superficial fascia of the anterior abdominal wall. If there is disruption of the spongy urethra, urine may extravasate into the superficial perineal pouch and ascend up the anterior abdominal wall beneath the deep membranous layer. It will not extend into the anal triangle because the superficial perineal fascia is tacked down to the perineal membrane along its posterior margin. It will not extend into the thigh because the superficial perineal fascia is tacked down to superomedial fascia lata of the thigh.
- Penile trauma is rare. Rupture of the tunica albuginea and bleeding into the deep fascia can result in swelling of the penis.

MEMORY AIDS

Erectile Dysfunction (ED): "**V**ery **N**ervous **P**eople **H**esitate and **D**isappoint"
Vascular
Neurologic
Psychogenic
Hormonal
Drugs

5.8 TESTIS, EPIDIDYMIS, AND DUCTUS DEFERENS

Study Aims

At the end of your study, you should be able to:

- Describe the gross structure of the testes
- Understand the organization of the ducts of the testes: seminiferous tubes, rete testis, efferent ductules
- Describe the basic structure of the epididymis
- Describe the course of the ductus deferens from the testes to the urethra
- Understand the anatomy of the seminal vesicles and their ducts in relation to the formation of the ejaculatory duct
- Know the location of the ejaculatory ducts and where they enter the urethra
- Know the anatomy and organization of the prostate gland
- Outline the contents of semen and the factors that control ejaculation

GUIDE

TESTES

- Ovoid structure, approximately 5 cm long
- Site of sperm production
- Contains 200 to 300 lobules separated by connective tissue septa
- 2 or 3 highly coiled seminiferous tubules in each lobule, 1 meter in length
- Tubules converge toward posterior testis and discharge contents into duct network of rete testis.
- Mediastinum testis
  - Posterior region of testis where vessels and nerves enter and leave
  - Not covered by tunica vaginalis
  - Contains rete testis
  - Contains efferent ductules connecting rete testis to head of epididymis
- Suspended by spermatic cord and located in scrotum
- Covered by three distinguishable layers
  - Tunica albuginea—tough fibrous layer
  - Visceral layer of tunica vaginalis—serous layer
    - Applied to testis, epididymis, and distal spermatic cord
  - Parietal tunica vaginalis
    - Parietal and visceral tunica vaginalis derived from peritoneal outpocketing in embryonic life
    - Separated by small amount of serous fluid that allows testis to move in scrotal sac
    - Deficient posteriorly to transmit epididymis and blood vessels
- Blood supply: testicular artery
- Venous drainage: pampiniform plexus

EPIDIDYMIS

- Formed from convolutions of narrow duct of the epididymis
- Located on posterior aspect testes within scrotum
- Consists of head, body, and tail
- Head formed from ends of approximately 12 efferent ductules from testis
- Tail continuous with ductus deferens
- Where sperm are stored, mature, and become motile
- Blood supply: testicular artery
- Venous drainage: pampiniform plexus

DUCTUS DEFERENS (VAS DEFERENS)

- 25 cm long
- Connects tail of epididymis to ejaculatory duct
- Course
  - Commences at tail of epididymis
  - Travels in spermatic cord (where it can be palpated) through superficial inguinal ring and through inguinal canal
  - Emerges at deep inguinal ring and crosses over external iliac vessels to run along lateral pelvic wall
  - Crosses above and medial to ureter, where it becomes dilated and forms the ampulla
  - Ampullae converge with each other on posterior aspect of bladder and narrow before uniting with duct of seminal vesicle to form ejaculatory duct
  - Ejaculatory duct opens into the prostatic urethra
- Blood supply: branch of inferior vesical artery = deferential artery
- Venous drainage: deferential vein(s) to prostatic venous plexus to internal iliac veins

SEMINAL VESICLES

- Elongated, coiled structures between fundus of bladder and rectum
- Separated from rectum by rectovesical pouch
- Do not store sperm
- Secrete alkaline fluid that mixes with sperms in ejaculatory ducts and urethra
- Duct of each seminal vesicle joins ductus deferens to form ejaculatory duct.
- Supplied by branches and tributaries of inferior and middle rectal vessels

EJACULATORY DUCTS

- Formed from union of ductus deferens with duct of seminal vesicle
- Short (approximately 2.5 cm)
- Converge and open on seminal colliculus of prostatic urethra as two slits
- Supplied by deferential arteries
- Drained by prostatic and vesical plexuses

PROSTATE

- Encapsulated gland surrounding urethra between neck of bladder and pelvic floor
- Directly behind inferior edge of pubic symphysis
- Composed of
  - Two lateral lobes
  - Anterior lobe or isthmus connecting lateral lobes anteriorly
  - Posterior lobe below ejaculatory ducts and posterior to urethra
  - Middle lobe between urethra and ejaculatory ducts
- Contains glands that produce 20% of volume of semen

- Ducts of glands combine to form prostatic ducts opening into prostatic sinuses on either side of seminal colliculus in prostatic urethra.
- Dense fascia sheath outside capsule contains prostatic venous plexus that drains to internal iliac veins.
- Supplied by prostatic arteries from several sources including internal iliac or inferior vesical arteries

ANATOMICAL POINTS

SEMEN CONTENTS

- Sperm from testes: 40 to 600 million per ejaculate but only 10% of total ejaculate
- Seminal vesicle secretions: alkaline fluid rich in fructose, 70% of total ejaculate
- Prostatic secretions: lipids, acid phosphatase, proteolytic enzymes, citric acid
- Other contents: potassium, zinc, citric acid, phosphorylcholine, spermine, free amino acids, and prostaglandins

MECHANISM OF EJACULATION

- Controlled by sympathetic nervous system
- Contraction of smooth muscle of ductus deferens, seminal vesicles, and prostate propels secretions into prostatic urethra.
- Simultaneous contraction of smooth muscle in bladder neck prevents retrograde ejaculation (reflux of semen into the bladder).
- Semen is expelled from the urethra by contraction of the bulbospongiosus muscles.

CLINICAL POINTS

HYDROCELE

- An accumulation of serous fluid in space between parietal and visceral layers of tunica vaginalis
- Presents as a fluctuant swelling in the testes
- Detection requires transillumination—bright light applied to the swelling presents as a red glow in a darkened room.
- May be congenital, precipitated by trauma or inflammation of the epididymis

VASECTOMY

- Method of birth control because it produces sterility
- Failure rate less than 95%
- Performed under local anesthetic
- Vas deferens is isolated via a small scrotal incision in superoanterior scrotal wall.
- A segment of duct is clamped or ligatured at each end; the segment is sectioned and the ends are cauterized.

TESTICULAR CANCER

- 95% are germ cell tumors.
- Nearly all are malignant.
- Peak incidence is 15 to 34 years
- Presents as firm, painless lump in testes or a reactionary varicocele
- Potentially curable with surgical resection (orchidectomy) if detected early
- Metastasizes to lumbar lymph nodes

MEMORY AIDS

Innervation of the penis

"Point and Shoot"—Erection ("**P**oint") is controlled by the **P**arasympathetic nervous system and ejaculation ("**S**hoot") by the **S**ympathetic nervous system.

"S2, 3, 4 keep the penis off the floor"—Innervation of the penis by branches of the pudendal nerve, derived from spinal cord levels S2–S4

5.9 RECTUM AND ANAL CANAL

Study Aims

At the end of your study, you should be able to:

- Describe the gross structure of the rectum, including its musculature
- List the relations of the rectum
- Outline the blood and vascular supply of the rectum
- Describe structures that may be palpated on digital rectal examination
- Describe the anatomy of the anus
- Describe the blood and vasculature supply to the different regions of the anus

GUIDE

RECTUM

Gross Structure

- Approximately 12 cm in length
- Part of large bowel
- Commences at level S3 vertebral body and follows curve of sacrum and coccyx
- Continuation of sigmoid colon at rectosigmoid junction
- Extends from rectosigmoid junction to anal canal (anorectal junction)
- Anorectal junction
  - Lies at level of pelvic floor
  - Puborectalis muscle forms a U-shaped sling at this point.
  - Perineal flexure annulates anorectal junction
  - Palpated as anorectal ring on digital rectal examination
- Three lateral curves/flexures in rectum (Upper and lower curves deviate to the right; the middle to the left.)
- Rectal ampulla
  - In region of middle and lower curves
  - Somewhat dilated
  - Very distensible
- Internal structure
  - Smooth mucosa, changes from rugose mucosa of sigmoid colon
  - Transverse rectal folds
    - Three infoldings of mucosa and submucosa project into lumen
    - Superior, middle, and inferior
    - Called rectal valves of Houston
    - Result from three lateral flexures

Relations

- Peritoneum
  - Upper third of rectum covered by peritoneum on anterior aspect and sides
  - Middle third of rectum covered by peritoneum on anterior surface only
  - Lower third of rectum below peritoneal reflection
- Pararectal fossae on lateral sides of rectum in peritoneal cavity
- Rectovesical septum of pelvic fascia separates rectum from prostate.
- Rectovaginal septum of pelvic fascia separates rectum from vagina.
- Lateral ligaments of rectum—condensations of pelvic fascia around middle rectal vessels

Relations of Rectum

Posterior	Sacrum
	Coccyx
	Piriformis muscle
	Superior rectal vessels
	Hypogastric plexus (ANS)
	Sympathetic trunk nerves
	Sacral plexus
Inferior	Levator ani muscles
Lateral	Pelvic plexus nerves (ANS)
	Ureters
Anterior	Sigmoid colon
	Ileum
Anterior structures palpable on rectal examination	Prostate (males)
	Base bladder
	Seminal vesicles (males)
	Ampullae of ductus deferens (males)
	Cervix (females)

Blood Supply

Arterial.

- Mainly by superior rectal artery (continuation of inferior mesenteric artery)
- Also supplied by middle rectal arteries (from internal iliac arteries) to middle and inferior parts
- Inferior rectal arteries supply anorectal junctions and anal canal.
- Superior, middle, and inferior rectal arteries anastomose with each other.

Venous.

- Chief drainage via a rectal venous plexus to the superior rectal vein
- Middle and inferior rectal veins also drain rectum.
- Superior rectal vein drains to portal system.
- Middle and inferior rectal veins drain to inferior vena cava via internal iliac vein.
- Anastomoses between these veins link portal and system systems.

Lymphatic Drainage.

- Lymphatic vessels from superior half of rectum drain to pararectal nodes and from there to inferior mesenteric and lumbar nodes.
- Lymphatic vessels from inferior half of rectum travel with middle rectal vessels to internal iliac nodes and anastomose with lymphatics of anal canal.

Innervation

- Sympathetic innervation
  - From lumbar sympathetic fibers via inferior mesenteric arteries and superior rectal arteries to superior rectal plexus to blood vessels of rectum
- Parasympathetic innervation
  - Main motor fibers to muscles of the rectal wall
  - From pelvic splanchnic nerves (S2–S4) via inferior hypogastric (pelvic) plexus to middle rectal plexus
- Visceral afferent (sensory) fibers travel via inferior hypogastric (pelvic) plexus and pelvic splanchnics back to spinal cord.

ANAL CANAL

Gross Structure

- Terminal part of gastrointestinal tract
- Approximately 3 cm long
- Commences at anorectal junction and ends at anus
- Encircled by internal and external sphincter muscles
- Descends between perineal body and anococcygeal ligament
- Mucosal lining of superior has longitudinal ridges—*anal columns.*
  - Inferior ends of columns are joined by anal valves.
  - Behind valves are small sinuses: anal sinuses.
  - Anal glands (mucus) empty into anal sinuses.
- Inferior end of anal valves forms an irregular line: *pectinate* (or *dentate*) *line.*
- Pectinate line divides superior portion of anal canal, derived from embryonic endoderm (hindgut), from inferior portion derived from ectoderm (proctodeum).
- Inferior half lined by nonkeratinized squamous epithelium (skin)
- Vascular, nerve, and lymphatic supply of these two regions are different as a result of different embryologic origin.

Vascular, Lymphatic, and Nerve Supply to Anal Canal

Supply	Above Pectinate Line	Below Pectinate Line
Arterial	Superior rectal artery	Inferior rectal arteries
Venous	Internal plexus drains to superior rectal vein and portal system	Internal venous plexus drains to inferior rectal veins and caval system
Lymphatic	To internal iliac and common iliac and lumbar nodes	To superficial inguinal nodes
Nerve	From inferior hypogastric (pelvic) plexus (both sympathetic and parasympathetic; sensitive to stretching only)	From inferior rectal nerves, branches of the pudendal nerves (sensitive to pain, temperature and touch)

- Has two sphincters: external (voluntary) and internal (involuntary)
  - External sphincter
    - Superficial, subcutaneous, and deep parts
    - Parts not readily distinguishable
    - Fibers attach to central perineal tendon (body) anteriorly and anococcygeal ligament posteriorly.
  - Internal sphincter: internal circular muscular layer continuous from rectum around upper two thirds of anal canal

Anorectal Musculature

Ischiorectal (Ischio-anal) Fossae.

- Fat-filled, wedge-shaped recesses on either side of anal canal
- Communicate with each other posteriorly over anococcygeal ligament
- Bounded by
  - Lateral: ischium and obturator internus muscle and fascia
  - Medial: anal canal surrounded by external anal sphincter
  - Anterior: external sphincter urethrae and deep transverse perineal muscles
  - Superior: pelvic diaphragm
  - Inferior: superficial perineal fascia and skin
- Filled with fat spanned by fibrous bands to support anal canal but compressible during defecation
- On lateral walls are found internal pudendal vessels and pudendal nerve within pudendal (Alcock's) canal in fascia of internal surfaces of obturator muscles.
- Extends anteriorly superior to perineal membrane as anterior recesses of ischiorectal (ischio-anal) fossae
- Important site of abscess formation

ANATOMICAL POINTS

MECHANISM OF DEFECATION (EMPTYING OF BOWEL)

- Occurs as the result of action of the pelvic splanchnic nerves—increase peristaltic action of rectum
- Feces move through anal canal.
- Pressure in rectum causes reflex contraction of external anal sphincter.
- Contraction of external anal sphincter causes relaxation of peristaltic contraction.
- External anal sphincter relaxes and defecation occurs.

CLINICAL POINTS

ANAL HEMORRHOIDS (VARICOSITIES)

- Can be internal or external
- Internal
  - Prolapses of mucosal lining containing internal venous plexus
  - Can prolapse through anal canal, become strangulated by sphincters, and ulcerate
  - Painless
- External
  - Blood clots in external venous plexus
  - Painful
- Caused by
  - Anything that increases intra-abdominal pressure, such as chronic constipation (straining) or pregnancy
  - Portal hypertension (cirrhosis of the liver)
- Varicosities of venous plexuses are normal.
- Internal hemorrhages can occur without portal hypertension.

ISCHIORECTAL AND PERI-ANAL ABSCESSES

A number of potential tissue spaces surround the anal canal and rectum and may become infected because of

- Inflammation of anal sinuses
- Extension of an infection from the pelvis
- Tear in the mucous membrane of the anal canal

Abscesses are classified according to the space occupied.

- Submucosal
- Peri-anal
- Intersphincteric
- Ischiorectal
- Perirectal

Peri-anal and ischiorectal account for approximately 80% of all abscesses.

RECTAL PROLAPSE

- Eversion of lower part of rectum and anal canal
- Occurs as result of weakness of pelvic floor muscles and breakdown of pelvic fascia
- Common in elderly (older than 80 years)
- More common in women, since perineum is weakened by childbirth

DIGITAL RECTAL EXAMINATION

- Performed with patient in left lateral position
- Peri-anal region is initially inspected for fistulae, fissures, skin tags, and prolapsed hemorrhoids.
- 90% of rectal cancers are palpable.
- Surfaces of sacrum and coccyx and ischial spines and tuberosities can be palpated.
- Enlarged internal iliac lymph nodes and ischiorectal (ischio-anal abscesses) can also be palpated)
- In men: prostate and seminal vesicles can be palpated anteriorly.
- In women: cervix can be palpated anteriorly.

5.10 VASCULATURE

Study Aims

At the end of your study, you should be able to:

- Describe the arterial blood supply of the pelvis and perineum
- Name the visceral and parietal branches of the internal iliac artery
- Outline the venous drainage of the pelvis and perineum
- Outline the lymphatic drainage of the pelvis and perineum

GUIDE

PELVIC VASCULATURE

Arterial Supply to the Pelvis

- Four arteries supply the true, or lesser, pelvis and its contents.
  - Paired internal iliac arteries
  - Paired ovarian arteries
  - Medial sacral artery
  - Superior rectal artery
- Main arterial supply is from branches of internal iliac artery.
- Medial sacral artery from abdominal aorta supplies lower lumbar vertebrae, sacrum, and coccyx.
- Superior rectal artery (branch inferior mesenteric artery) supplies upper region of rectum.
- Ovarian arteries (from abdominal aorta) supply ovaries, descending in suspensory ligament of ovary.
- Internal iliac artery
  - One of two terminal branch common iliac arteries (other is external iliac)
  - Common iliac bifurcates anterior to sacro-iliac joint.
  - Internal iliac artery is crossed by ureter at its origin.
  - Passes posteromedially into true pelvis beneath peritoneum, giving off branches to buttocks, thigh, perineum, and pelvic viscera. Usually ends at level of superior edge of greater sciatic foramen by dividing into anterior and posterior divisions.

Branches of Internal Iliac Artery and Structures Supplied.

Visceral Vessels	**Structures Supplied**	**Comment**
Umbilical artery	Superior urinary bladder via superior vesical	From anterior division of internal iliac
	Artery to ductus deferens in males	Obliterates and becomes median umbilical ligament
Superior vesical artery	Superior urinary bladder	From proximal part of umbilical
	Ureter in pelvis	Branch given to ductus deferens
Inferior vesical artery	Inferior urinary bladder	From anterior division of internal iliac
	Prostate	Only exists in males
	Seminal vesicles	
	Ductus deferens	
Uterine artery	Vagina	From anterior division of internal iliac
	Uterus	Terminates by anastomosing with ovarian artery
	Uterine tubes	
Middle rectal artery	Inferior rectum	From anterior division of internal iliac
	Seminal vesicles	
	+/– prostate	
Vaginal artery	Vagina	From uterine
	Cervix	
	Inferior urinary bladder	
Parietal Branches	**Structures Supplied**	**Comment**
Obturator artery	Pelvic muscles	From anterior division of internal iliac
	Head of femur	Runs through obturator canal with obturator vein and artery
	Muscles of medial compartment thigh	Occasionally can take origin from inferior epigastric artery
Superior gluteal artery	Piriformis muscle	From posterior division of internal iliac
	All three gluteal muscles	Exits via greater sciatic foramen above piriformis muscle
	Tensor fascia lata	
Inferior gluteal artery	Pelvic diaphragm	From anterior division of internal iliac
	Piriformis	Exits via greater sciatic foramen below piriformis muscle
	Quadratus femoris	
	Gluteus maximus	
	Hamstring muscles	
Internal Pudendal Artery	Muscles and skin of anal and urogenital triangles	From anterior division of internal iliac
	Erectile bodies	Passes through greater sciatic foramen below piriformis and enters perineum via lesser sciatic foramen
Iliolumbar artery	Psoas major	From posterior division of internal iliac
	Iliacus	Ascends deep to common iliac and anastomoses with lower lumbar arteries
	Quadratus lumborum	
Lateral sacral artery	Piriformis	From posterior division of internal iliac
	Contents of sacral canal	Runs on piriformis
	Erector spinae	Sends branches into pelvic sacral foramina

Venous Drainage of the Pelvis

- Veins accompany main branches of internal iliac artery.
- Around pelvic organs they anastomose to form venous plexuses: rectal, vesical, prostatic, uterine, and vaginal.
- Extensive prostatic venous plexus and anastomoses occur around pelvic viscera in males.
- Extensive anastomoses and venous plexus surround uterus and vagina in females.
- Venous plexuses communicate with each other.
- Veins and plexuses eventually drain into internal iliac vein.
- Some venous blood from pelvis drains to internal vertebral venous plexus.
- Internal iliac veins are found deep to arteries.
- Become confluent with external iliac veins to form common iliac veins
- Portacaval anastomosis occurs between superior rectal vein and inferior rectal veins.

Vasculature Supply of the Pelvic Organs

Organ	Blood Supply	Venous Drainage
Pelvic Organs Common to Male and Female		
Ureter	Renal, gonadal, common iliac, uterine/ inferior vesical, and middle rectal arteries	Parallel to arteries
Urinary bladder	Superior and inferior vesical arteries of anterior division of internal iliac artery	Internal iliac vein via vesical and prostatic venous plexuses
Male Pelvic Structures		
Seminal glands	Branches of inferior vesical and middle rectal arteries	Drain to internal iliac veins
Ductus deferens	Inferior epigastric artery, inferior vesical, and middle rectal arteries	Drain to internal iliac veins
Prostate gland	Inferior vesical and middle rectal arteries	Prostatic venous plexus receives deep dorsal vein of penis and vesical veins. It drains into internal iliac veins
Female Pelvic Structures		
Ovary	Ovarian artery from abdominal aorta, which anastomoses with uterine artery (branch of internal iliac artery)	Ovarian vein drains to inferior vena cava on right and left renal vein on left
Uterine tube	Ovarian artery from abdominal aorta, which anastomoses with uterine artery (branch of internal iliac artery)	Ovarian vein drains to inferior vena cava on right and left renal vein on left
Uterus	Branches of ovarian artery (from aorta), uterine and vaginal arteries (from internal iliac artery)	Ovarian vein (see ovary), uterine, and vaginal veins (drain to internal iliac veins)

Lymphatic Drainage of the Pelvis

- Lymphatic vessels accompany arteries.
- Most lymph drains to internal iliac nodes and then to common iliac nodes.
- Ovaries, testes, and rectum drain to aortic nodes.
- Some vessels from body of uterus drain to superficial inguinal nodes, following round ligament of the uterus.

PERINEAL VASCULATURE

Arterial Supply of the Perineum

- Mainly from internal pudendal artery (branch internal iliac artery)
- Supplies muscles and skin of anal and urogenital triangles, erectile bodies of perineum
- Internal pudendal artery
  - Passes through greater sciatic foramen inferior to piriformis muscle
  - Loops around sacrospinous ligament
  - Enters lesser sciatic foramen to reach ischio-anal (ischiorectal) fossa and perineum
  - Traverses fossa in pudendal (Alcock's) canal
  - Gives off branches before entering canal and in pudendal canal
  - Medial to ischial tuberosity, terminates as deep and dorsal arteries of penis (or clitoris)

Branches of Internal Pudendal Artery Supplying Perineum

Branch	Structure Supplied	Comment
Inferior rectal artery	Anal canal	
Posterior scrotal (labial) artery	Scrotum (labia in females)	
Branch to bulb of penis	Bulb of penis (vestibule in females)	
Branch to crus of penis	Crus of penis (clitoris in females)	
Dorsal artery of penis (clitoris)	Erectile tissue corpus cavernosum	Smaller artery in females
Deep artery of the penis (clitoris)	Erectile tissue corpus cavernosus	Smaller artery in females

Venous Drainage of the Perineum

- Branches of internal pudendal artery accompanied by venae comitantes
- Drain into internal iliac vein

Lymphatic Drainage of the Perineum

- Penis and vulva drain to the superficial inguinal nodes

CLINICAL POINTS

VARICOCELE

- Abnormal dilatation of pampiniform venous plexus
- Almost always left-sided because left testicular vein drains into left renal vein not inferior vena cava as on the right
- Seen when patient stands, disappears on lying down
- Caused by defective valves in testicular artery or problem with left renal vein

5.11 INNERVATION

Study Aims

At the end of your study, you should be able to:

- Describe the formation of the sacral plexus
- Know the main branches of this plexus and what they supply
- Describe the parasympathetic innervation of the pelvis
- Describe the sympathetic innervation of the pelvis
- Describe the innervation of the perineum

GUIDE

- Pelvic innervation is both somatic and autonomic.
- Many nerves pass through the pelvis without innervating any structures.

SACRAL PLEXUS (SOMATIC CONTRIBUTION)

- Located on posterior wall of true pelvis on anterior surface of piriformis muscle
- Formed by ventral rami of S1–S4 spinal nerves and lumbosacral trunk, formed from fibers from ventral rami of L4–L5 spinal nerves
- Branches supply lower limb, pelvic floor and wall and perineum; most branches leave the pelvis through greater sciatic foramina.
- Two major branches are sciatic nerve and pudendal nerve

Branches of the Sacral Plexus

Nerve	Structures Supplied	Spinal Nerve Origin
Major Branches		
Sciatic	Hip joint Flexor muscles of knee Muscles of leg and foot	L4–L5, S1–S3
Pudendal	Sensory and motor to all structures in the perineum	S2–S4
Superior gluteal	Gluteus medius and minimus muscles	L4–L5, S1
Inferior gluteal	Gluteus maximus muscle	L5, S1–S2
Posterior femoral cutaneous	Sensory to buttock, superior medial, and posterior thigh	S2–S3
Minor Branches		
Nerve to piriformis	Piriformis muscle	S1–S1
Nerve to obturator internus and superior gemellus muscles	Obturator internus and superior gemellus muscles	L5, S1–S2
Nerve to quadratus femoris and inferior gemellus muscles	Quadratus femoris and inferior gemellus muscles	L4–L5, S1
Nerve to levator ani and coccygeus	Pelvic diaphragm	S3–S4

AUTONOMIC NERVES

Sympathetic Innervation

- Sympathetic trunks
  - Contain fibers from lower thoracic and upper lumbar spinal segments
  - Descend on posterior abdominal wall on either side of vertebral bodies
  - Descend behind common iliac artery, in front of sacrum and piriformis muscle
  - Fuse on anterior surface of coccyx as ganglion impar
  - Source of sacral splanchnic nerves that join inferior hypogastric (pelvic) plexus in pelvis
  - Contain either postsynaptic fibers from synapses in ganglia superiorly or presynaptic fibers that will synapse in one of four sympathetic ganglia in pelvis
  - Primary function is to send postsynaptic fibers to sacral spinal nerves via gray rami communicantes

  - No white rami communicantes associated with sacral sympathetic trunks because sympathetic outflow is thoracolumbar
- Lumbar splanchnics join superior hypogastric plexus
- Superior hypogastric plexus
  - Located just below bifurcation of aorta
  - Continuation of intermesenteric/aortic plexus
  - Contains no parasympathetic fibers
  - Contains visceral afferents ascending from the pelvis
  - Continues into pelvis as loose collections of fibers in either side of anterior sacrum = right and left hypogastric nerves
  - Spreads out in pelvis as inferior hypogastric (pelvic) plexus
- Functions
  - Vasomotor, pilomotor, secretory to sweat glands to skin of perineum and lower limb
  - Controls ejaculation (in males)
  - Innervates smooth muscle of blood vessels in pelvis and smooth muscle of some organs

Parasympathetic Innervation

- From pelvic splanchnic nerves
  - Outflow from 2nd to 4th sacral spinal cord segment
  - Contain visceral afferents
- Controls micturition, erection, and defecation
- Innervates descending and sigmoid colon via fibers ascending in sigmoid mesentery and parietal peritoneum of left side of posterior abdominal wall

INFERIOR HYPOGASTRIC (PELVIC) PLEXUS

General Structure

- Formed from fibers of hypogastric nerves, sacral splanchnic nerves, and pelvic splanchnic nerves
- Lies on posterolateral pelvic wall internal to internal iliac arteries and their branches
- Gives off
  - Middle rectal plexus
  - Uterovaginal plexus (females)
  - Vesical plexus
  - Deferential plexus
  - Prostatic plexus (males
  - Cavernous nerves (nervi erigentes) to erectile tissue of penis and clitoris
- Except for cavernous nerves, nerves in various plexuses reach viscera in company with relevant branches of internal iliac artery.
- Branches transmit efferents from both sympathetic and parasympathetic nervous systems and visceral afferents.

Contents

- Presynaptic and postsynaptic sympathetic fibers from superior hypogastric plexus via hypogastric nerves
- Postsynaptic sympathetic fibers from sacral splanchnic nerves
- Sympathetic ganglia
- Visceral afferent fibers that either ascend along hypogastric nerves or return to CNS via pelvic splanchnic nerves, depending on information carried
- Presynaptic parasympathetic fibers from pelvic splanchnic nerves
- Enteric parasympathetic ganglia where plexus lies on or near a pelvic viscus
- Postsynaptic parasympathetic fibers from enteric ganglia to viscus innervated

CLINICAL POINTS

- The obturator nerve and vessels cross the floor of the ovarian fossa; therefore, ovarian disease such as malignancy can present with referred pain to medial aspect of thigh.
- After a radical prostatectomy (removal of the prostate gland, seminal vesicles, and periprostatic tissue) for localized prostate cancer, erectile dysfunction can occur because of inadvertent damage to the cavernous nerves (*nervi erigentes*), the parasympathetic fibers from the pelvic plexus that govern erection.

PUDENDAL NERVE BLOCK

- Performed to relieve perineal pain during childbirth
- Anesthetic agent is injected into tissues around pudendal nerve.
- Injection is normally done transvaginally.
- Physician palpates the ischial spine and uses his fingers to direct the needle so that the anesthetic is injected in the region of the ischial spine, where the pudendal nerve wraps around it to enter the lesser sciatic foramen.
- Pudendal blocks do not relieve the pain of contractions.

MEMORY AIDS

S 2, 3, 4 keeps the poo off the floor

Defecation is controlled by parasympathetic fibers to the rectum and anal canal from the pelvic splanchnic nerves via the pelvic plexus. These nerves arise from S2, S3, and S4 spinal cord levels.

Upper Limb Study Guide

6

6.1 TOPOGRAPHIC ANATOMY

Study Aims

At the end of your study, you should be able to:

- Identify the bony landmarks: acromion, coracoid process of scapula, olecranon and head of ulna, medial and lateral epicondyles, radial styloid process
- Identify the muscle masses of the deltoid, biceps, triceps, brachioradialis, and thenar and hypothenar eminences
- Identify the deltopectoral triangle and cubital fossa
- Identify the course of the cephalic, basilic and median cubital veins

GUIDE

BONES

- Clavicle: subcutaneous; palpable throughout its length
- Acromion: easily palpable, traced medially to acromioclavicular joint *(see Section 6.2, Shoulder and Axilla)*
- Coracoid process of scapula: palpable deep and lateral to deltopectoral triangle
- Head of humerus: palpable deep to deltoid inferior to lateral edge of acromion when arm is rotated
- Elbow: palpable medial and lateral epicondyles of humerus and visible olecranon process of ulna *(see Section 6.4, Elbow and Forearm)*
- Head of radius: palpable as it rotates during pronation and supination on posterolateral aspect of extended elbow, just distal to lateral epicondyle
- Ulnar head: visible on medial side of dorsal aspect of wrist *(see Section 6.5, Wrist and Hand)*
- Radial styloid: palpable in anatomical snuff box on lateral side of wrist
- Ulnar styloid: just distal to ulnar head with hand supinated
- Pisiform: hard, round structure on anteromedial aspect of wrist
- Tubercles of scaphoid and trapezium: palpable at proximal end of thenar eminence

MUSCLES AND TENDONS

- Deltoid muscle: Overlies shoulder, giving it rounded appearance
- Biceps: Bulge on anterior aspect of arm
- Biceps brachii tendon: palpable in cubital fossa, lateral to midline with arm flexed
- Flexor tendons: wrist and finger flexors visible distally on ventral aspect of forearm
- Extensor tendons: wrist and finger flexors visible on the dorsum of hand
- Thenar eminence: muscles at base of thumb *(see Section 6.5, Wrist and Hand)*
- Hypothenar eminence: muscles at base of little finger *(see Section 6.5, Wrist and Hand)*

ARTERIES AND VEINS

- Brachial artery
  - Pulsations can be palpated deep to medial border of biceps muscle
  - Used to determine heart rate in children
- Radial artery: pulse can be felt by compressing artery against distal end of radius
- Median cubital vein *(see Section 6.4, Elbow and Forearm)*
  - Traverses cubital fossa connecting cephalic to basilic veins
  - Often used for venipuncture
- Cephalic vein ascends along lateral forearm and arm *(see Section 6.6, Neurovasculature)*
- Basilic vein ascends along medial forearm and distal arm *(see Section 6.6, Neurovasculature)*
- Dorsal venous network seen on dorsum of hand

NERVES

- Ulnar nerve can be felt under medial epicondyle

ANATOMICAL POINTS

FUNCTIONAL OVERVIEW

The upper limb is highly mobile and characterized by its ability to perform a wide range of controlled movements to manipulate the surrounding environment. It is suspended from the trunk at the shoulder, and its stability has been sacrificed to gain mobility. Clinically the limb is divided into four regions: pectoral girdle, arm, forearm and hand.

UPPER LIMB DEVELOPMENT

The upper limb buds from the embryonic trunk and rotates 90 degrees laterally, so in the anatomical position, the ventral structures face anteriorly and the dorsal structures posteriorly. This contrasts with the medial rotation of the lower limb. Thus, the upper and lower limbs are 180 degrees out of phase. Flexors of all joints in the upper limb are anterior and extensors are posterior.

CLINICAL POINTS

WINGED SCAPULA

Normally the scapula is held closely against the posterior thoracic wall. Damage to the long thoracic nerve to serratus anterior (which courses superficially over the muscle) causes "winging" of the scapula as its medial border lifts away from the thorax when the arm is raised. This is accentuated when the individual leans on the hand or pushes the upper limb against a wall. Most importantly, the arm cannot be abducted above the horizontal plane because glenoid cavity cannot be rotated upward without the action of the serratus anterior.

6.2 SHOULDER AND AXILLA

Study Aims

At the end of your study, you should be able to:

- Identify the different parts and surface markings of the clavicle and scapula
- Describe the sternoclavicular, acromioclavicular, and glenohumeral joints, their movements, and supporting ligaments
- Understand the organization of the scapular muscles
- Know the origins, insertions, and actions of the intrinsic scapular muscles
- Identify the boundaries of the axilla and describe its contents
- Describe the organization of the deep fascia

GUIDE

BONES

- Clavicle: sternal and acromial ends
  - Double-curved long bone
  - Sternal end articulates with manubrium of sternum
  - Acromial end articulates with acromion
  - Osteological features
    - Deltoid tubercle for attachment of deltoid muscle
    - Conoid tubercle for attachment of conoid ligament
    - Subclavian groove for attachment of subclavius muscle
    - Trapezoid line where trapezoid ligament attaches
  - Serves as a strut suspending scapula and limb with maximum freedom
- Scapula: lying against posterolateral thorax
  - Triangular, flat bone
  - Lies posterolateral on 2nd through 7th ribs
  - Osteological features
    - Concave costal surface = subscapular fossa
    - Posterior surface divided by spine = transverse ridge of bone
    - Supraspinous fossa
    - Infraspinous fossa
    - Acromion = flattened lateral end of spine
    - Coracoid process = anterior projection above glenoid cavity
    - Glenoid cavity = socket for head of humerus
    - Suprascapular notch (scapular notch) = notch found on superior border, two thirds of way along laterally
  - Capable of considerable movement over thoracic wall

JOINTS

- Sternoclavicular joint
  - Saddle-type, synovial joint
  - Divided into two compartments by an articular disc
  - Movements
    - Elevation with posterior rotation
    - Protraction
    - Depression
  - Articulation between concave facet of manubrium and concave facet of clavicle
  - Strengthened by anterior and posterior sternoclavicular, costoclavicular, and interclavicular ligaments
  - Blood supply: branches of suprascapular and internal thoracic arteries
  - Nerve supply: branches of supraclavicular nerve and nerve to subclavius
- Acromioclavicular joint
  - Plane-type, synovial joint
  - No demonstrable movement; muscles moving scapula cause acromion to move on clavicle
  - Articulation between concave facet of acromion and convex facet of clavicle
  - Strengthened by acromioclavicular and coracoclavicular (conoid and trapezoid) ligaments
  - Coracoclavicular
    - Unites coracoid process and clavicle
    - Two component ligaments: *conoid*: vertical, in shape of inverted pyramid; *trapezoid*: horizontal, extends laterally to inferior surface of clavicle
  - Blood supply: branches of suprascapular and thoracoacromial arteries
  - Nerve supply: branches of supraclavicular, lateral pectoral, and axillary nerves
- Shoulder (glenohumeral) joint
  - Multiaxial, synovial ball-and-socket joint
  - Movements
    - Flexion/extension
    - Abduction/adduction
    - Internal/external (medial/lateral) rotation
    - Circumduction
  - Articulation of head of humerus with shallow glenoid cavity of scapula
  - Joint socket deepened by glenoid labrum (fibrocartilaginous ring) and supported by the rotator cuff muscles (*see below*)
  - Loose fibrous capsule encloses and contains two apertures
    - Between tubercles of humerus for passage of long head of biceps brachii, which attaches to supraglenoid tubercle within joint
    - Anterior opening, inferior to coracoid process, for communication between subscapular bursa and synovial cavity of joint
  - Blood supply: branches of anterior and posterior circumflex humeral arteries from axillary and suprascapular artery from subclavian

- Nerve supply: branches of suprascapular, axillary, and lateral pectoral nerves
- Ligaments of glenohumeral joint
  - Glenohumeral ligaments—strengthen capsule anteriorly
  - Coracohumeral ligament—strengthens joint superiorly
  - Transverse humeral ligament—bridges gap between greater and lesser tubercle and holds tendon of biceps brachii in place
  - Coraco-acromial ligament—from acromion to coracoid process, prevents displacement of humeral head superiorly

Ligament	Attachments	Comment
Joint capsule	Margin of glenoid cavity → anatomical neck of humerus	Loose fibrous capsule Weakest inferiorly
Glenohumeral	Supraglenoid tubercle → blend with fibrous capsule (superior, middle and inferior bands)	Reinforce anterior capsule
Coracohumeral	Coracoid process → greater tubercle of humerus	Strong
Transverse humeral	Bridges intertubercular groove between greater and lesser tubercles	Holds tendon of biceps brachii in intertubercular groove
Coraco-acromial	Coracoid process → acromion	Completes coraco-acromial arch protecting humeral head

BURSAE (IMPORTANT ONES)

- Contain thin layer of synovial fluid
- Located where tendons rub against bone, ligaments, or tendons and when skin moves over bone directly beneath
- Subscapular bursa
  - Between tendon of subscapularis muscle and neck of scapula
  - Communicates with cavity of shoulder joint
- Subacromial (subdeltoid) bursa
  - Between deltoid, supraspinatus tendon, and glenohumeral capsule
  - Does not communicate with cavity of shoulder
  - Facilitates movement of deltoid over joint capsule and supraspinatus tendon under coraco-acromial arch

MUSCLES OF THE SCAPULA

- Superficial extrinsic (join axial skeleton to appendicular skeleton)
  - Trapezius
  - Latissimus dorsi

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Trapezius	Superior nuchal line, external occipital protuberance, nuchal ligament, and spinous processes of C7–T12	Lateral third of clavicle, acromion, spine of scapula	Spinal root of accessory nerve (CN XI) and C3 and C4	Elevates, retracts, and rotates scapula; lower fibers depress scapula	Transverse cervical artery, dorsal perforating branches of posterior intercostal arteries
Latissimus dorsi	Spinous processes of T7–L5, thoracolumbar fascia, iliac crest, and last three ribs	Humerus (intertubercular sulcus)	Thoracodorsal nerve (C6–C7)	Extends, adducts, and medially rotates humerus at shoulder	Thoracodorsal artery, dorsal perforating branches of 9th, 10th, and 11th posterior intercostal, subcostal, and first three lumbar arteries

- Deep extrinsic
  - Levator scapulae
  - Rhomboid major and minor

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Levator scapulae	Posterior tubercles of transverse processes of C1–C4	Medial border of scapula from superior angle to spine	Ventral rami of C3–C4 and dorsal scapular nerve	Elevates scapula medially, inferiorly rotates glenoid cavity	Dorsal scapular artery, transverse cervical artery, ascending cervical artery
Rhomboid minor	Ligamentum nuchae, spines of C7 and T1 vertebrae	Medial border of scapula above base of spine of scapula	Dorsal scapular nerve (C4–C5)	Fixes scapula to thoracic wall and retracts and rotates it to depress glenoid cavity	Dorsal scapular artery OR deep branch of transverse cervical artery, dorsal perforating branches of the upper five or six posterior intercostal arteries
Rhomboid major	Spinous processes of T2–T5 vertebrae	Medial border of scapula below base of spine of scapula	Dorsal scapular nerve (C4–C5)	Fixes scapula to thoracic wall and retracts and rotates it to depress glenoid cavity	Dorsal scapular artery OR deep branch of transverse cervical artery, dorsal perforating branches of the upper five or six posterior intercostal arteries

- Intrinsic
  - Deltoid: gives shoulder its rounded appearance, abducts arm past 15 degrees
  - Teres major: adducts and medially rotates arm
  - Teres minor: hidden by deltoid, assists lateral rotation of arm and adduction
  - Supraspinatus: initiates arm abduction
  - Infraspinatus: laterally rotates arm
  - Subscapularis: primary medial rotator of the arm, also adducts

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Deltoid	Lateral third of anterior clavicle, lateral acromion, inferior edge of spine of scapula	Deltoid tuberosity of humerus	Anterior and posterior branches of axillary nerve (C5,C6)	*Clavicular part:* flexes and medially rotates arm; *Acromial part:* abducts arm beyond initial 15 degrees done by supraspinatus; *Spinal part:* extends and laterally rotates arm	Posterior circumflex humeral artery, deltoid branch of thoraco-acromial artery
Supraspinatus	Supraspinous fossa of scapula	Superior facet of greater tubercle of humerus	Suprascapular nerve (C5,C6)	Initiates arm abduction, acts with rotator cuff muscles	Suprascapular artery
Infraspinatus	Infraspinous fossa of scapula and deep fascia	Middle facet of greater tubercle of humerus	Suprascapular nerve (C5,C6)	Lateral rotation of arm (with teres minor)	Suprascapular artery
Teres minor	Upper two thirds of posterior surface of lateral border of scapula	Inferior facet of greater tubercle of humerus	Posterior branch of axillary nerve (C5,C6)	Laterally rotates arm	Circumflex scapular artery
Teres major	Posterior surface of inferior angle of scapula	Medial lip of intertubercular sulcus of humerus	Inferior subscapular nerve (C5,C6)	Adducts and medially rotates arm	Circumflex scapular artery
Subscapularis	Subscapular fossa	Lesser tubercle of humerus	Superior and inferior subscapular nerves (C5–C6)	Medially rotates arm and adducts it; helps hold humeral head in glenoid cavity	Subscapular artery, lateral thoracic artery

- Rotator cuff
  - Four scapulohumeral muscles
    - Supraspinatus
    - Infraspinatus
    - Teres minor
    - Teres major
  - Form musculotendinous cuff around glenohumeral joint
  - Blend with articular capsule to reinforce it
  - Hold head of humerus in glenoid cavity

AXILLA

- Pyramid-shaped area inferior to glenohumeral joint containing important neurovascular structures to upper limb
- Boundaries
  - Base: skin of armpit and axillary fascia from arm to thoracic wall
  - Apex: bounded by 1st rib, clavicle, and superior border of scapula
  - Anterior wall (anterior axillary fold): pectoralis major and minor
  - Posterior wall (posterior fold): subscapularis, teres major, latissimus dorsi
  - Medial wall: 1st through 4th ribs, serratus anterior, and intercostal muscles
  - Lateral wall: intertubercular groove of humerus
- Contents *(see Section 6.6, Neurovasculature, for details)*
  - Axillary artery and branches
  - Axillary vein and tributaries
  - Axillary lymph nodes (five major collections)
  - Brachial plexus
- Fascia
  - Pectoral fascia
    - Attaches to clavicle and sternum
    - Invests pectoralis major
    - Extends laterally as axillary fascia
    - Continues inferiorly with fascia of abdominal wall
  - Clavipectoral fascia
    - Invests subclavius and pectoralis minor
    - Continues superiorly as costocoracoid membrane (pierced by lateral pectoral nerve)
  - Axillary sheath: invests axillary artery and brachial plexus
- Axillary lymph nodes
  - Arranged in five main groups
  - Apical group
    - Along medial side of axillary vein and first part of axillary artery
    - Receives lymph from all other groups
    - Efferent lymphatic vessels from these nodes form subclavian lymphatic trunk.
  - Pectoral (anterior) group
    - Medial wall of axilla
    - Receives lymph from breast, anterior thoracic wall
  - Subscapular group
    - Along posterior axillary fold
    - Receives lymph from posterior thoracic wall and scapula
  - Humeral (lateral) group
    - Along lateral wall of axilla
    - Receives lymph from upper limb
  - Central group
    - Deep to pectoralis minor
    - Receives lymph from pectoral, subscapular, and humeral groups

CLINICAL POINTS

FRACTURE OF THE CLAVICLE

- Common, especially in children
- Usually results from a fall on outstretched hand or direct trauma to the shoulder
- Fractures of middle third are most frequently seen.
- Sternocleidomastoid muscle pulls the proximal fragment superiorly and the shoulder pulls the distal fragment inferiorly.
- Small lump may remain after the clavicle has healed.

CALCIFIC SUPRASPINATUS TENDONITIS

- Inflammation and calcification of the subacromial bursa resulting in pain, tenderness, and limitation of movement of the shoulder joint
- Calcium deposits frequently also seen in the supraspinatus tendon.
- Pain is especially severe with the arm abducted between 50 to 130 degrees *(the painful arc)* as the supraspinatus tendon is in contact with the inferior surface of the acromion here.

SHOULDER DISLOCATION

- High mobility and instability of the glenohumeral joint leads to frequent dislocation.
- 95% of dislocations are in anteroinferior direction, caused by excessive extension and lateral rotation of humerus (e.g., in the throwing motion).
- Humeral head places stress on joint capsule, which may be torn anteriorly, with elements of the rotator cuff.
- Axillary and musculocutaneous nerves may also be injured.
- Posterior dislocation is uncommon but may occur during epileptic seizure or electrocution.

ROTATOR CUFF INJURY

- Musculotendinous rotator cuff may be damaged by trauma or degenerative disease.
- One or more of tendons may be torn when the arm is forcefully abducted, leading to pain in the anterosuperior aspect of the shoulder.
- Supraspinatus tendon is most commonly involved in degenerative tendonitis.
- Leads patient's arm to drop suddenly at approximately 90-degree abduction, when instructed to lower it slowly from a fully abducted position

MEMORY AIDS

Rotator cuff muscles: **SITS = S**upraspinatus, **I**nfraspinatus, **T**eres minor, **S**ubscapularis

6.3 ARM

Study Aims

At the end of your study, you should be able to:

- Identify the different parts and surface markings of the humerus
- Describe the organization of the deep fascia and compartments of the arm
- Know the origins, insertions, and actions of the muscles of the arm
- Know the cutaneous nerves of the arm
- Describe the boundaries and contents of the cubital fossa

GUIDE

HUMERUS

- Largest bone of upper limb
- Osteological features
  - Head
  - Anatomical neck—circumscribes head above tubercles
  - Surgical neck: below tubercles—common site of fracture
  - Greater and lesser tubercles
  - Intertubercular groove
  - Body
    - Deltoid tuberosity for attachment of deltoid muscle
    - Radial groove on posterior surface where radial nerve and deep brachial artery traverse
  - Medial and lateral supracondylar ridges—widening of humerus distally as sharp ridges on either side
  - Medial epicondyle
    - Prominent lateral extension at distal end
    - Common origin of forearm flexors; ulnar nerve posterior
  - Lateral epicondyle
    - Prominent medial extension at distal end
    - Common origin of forearm extensors; radial nerve posterior
  - Condyle—distal end of humerus
    - Trochlea
      - Medial articular surface of condyle
      - For articulation with trochlear notch of ulna
    - Capitulum
      - Lateral articular surface of condyle
      - For articulation with head of radius
    - Coronoid fossa (see also Section 6.4, Elbow and Forearm)
      - Superior to trochlea
      - Receives coronoid process of ulna
    - Olecranon fossae
      - Posterior distal end of humerus
      - Receives olecranon of ulna during full extension of forearm at elbow

FASCIA OF THE ARM

- Brachial fascia
  - Sleeve of deep fascia around arm
  - Continuous with antebrachial fascia of forearm
- Medial and lateral intermuscular septa
  - Extend from deep surface of brachial fascia to humerus
  - Divide arm into anterior (flexor) and posterior (extensor) compartments
- Medial septum: medial lip of intertubercular sulcus (superiorly) → medial epicondyle
- Lateral septum: lateral lip of intertubercular sulcus (superiorly) → lateral epicondyle

MUSCLES OF THE ARM

- Anterior (flexor) compartment
  - Biceps brachii
    - Flexes and supinates
    - Continues distally as bicipital aponeurosis: triangular membrane from biceps tendon across cubital fossa and blends with antebrachial fascia over flexor muscles of forearm
  - Brachialis: main flexor of forearm
  - Coracobrachialis
    - Flexes and adducts arm
    - Pierced by the musculocutaneous nerve
- Posterior (extensor) compartment
  - Triceps brachii
    - Main extensor of arm
    - Stabilizes head of humerus in glenohumeral joint
  - Anconeus: extends arm and resists adduction of the ulna during pronation

Muscles	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Biceps brachii	*Long head*: supraglenoid tubercle of scapula; *Short head*: tip of coracoid process of scapula	Radial tuberosity, fascia of forearm via bicipital aponeurosis	Musculocutaneous nerve (C5,C6)	Flexes and supinates forearm at elbow	Muscular branches of brachial artery
Coracobrachialis	Tip of coracoid process of scapula	Middle third of medial surface of humerus	Musculocutaneous nerve (C5,C6,C7)	Flexes and adducts arm at shoulder	Muscular branches of brachial artery

Muscles	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Brachialis	Distal half of anterior surface of humerus	Coronoid process and tuberosity of ulna	Musculocutaneous nerve and radial nerve (C7)	Flexes forearm at elbow	Radial recurrent artery, muscular branches of brachial artery
Triceps brachii	*Long head*: infraglenoid tubercle of scapula; *Lateral head*: upper half of posterior humerus; *Medial head*: distal 2/3 of medial and posterior humerus	Posterior surface of olecranon process of ulna	Radial nerve (C6,C7,C8)	Extends forearm at elbow; long head stabilizes head of abducted humerus and extends and adducts arm at shoulder	Branch of profunda brachii artery

CUTANEOUS NERVES OF ARM

- Supraclavicular nerves (C4,C5) supply skin over shoulder
- Superior lateral cutaneous nerve (C5,C6)
  - Branch of axillary
  - Supplies skin over upper lateral arm
- Inferior lateral cutaneous nerve (C5,C6)
  - Cutaneous branch of radial nerve
  - Supplies skin over lower lateral arm
- Intercostobrachial nerve (T2)
  - Lateral cutaneous branch of 2nd intercostal nerve
  - Supplies upper medial arm anteriorly and posteriorly
- Medial brachial cutaneous nerve (C8–T1)
  - Branch of brachial plexus
  - Supplies lower anterior medial arm
- Posterior brachial cutaneous nerve (C5–C8)
  - Branch of radial nerve
  - Supplies lower posterior medial arm

CUBITAL FOSSA

- Boundaries
  - Superior: (imaginary) line connecting medial and lateral epicondyles
  - Medial: pronator teres muscle
  - Lateral: brachioradialis
  - Floor: brachialis and supinator muscles of arm and forearm
  - Roof: deep fascia, bicipital aponeurosis, subcutaneous tissue, and skin
- Contents
  - Brachial artery (terminal part)
  - Biceps brachii tendon
  - Nerves: median (in subcutaneous connective tissue)
  - Medial and lateral antebrachial cutaneous nerves
  - Basilic and cephalic veins
  - Median cubital vein (in floor of fossa)
  - Deep and superficial branches of radial nerve

CLINICAL POINTS

FRACTURE OF THE HUMERUS

- Fractures of humerus most common at surgical neck
- Especially common in elderly individuals with osteoporotic bone, falling on outstretched arm
- Axillary nerve vulnerable to damage here
- Direct blow to the arm may:
  - Fracture humerus through its midshaft, with risk of injury to radial nerve
  - Fracture humerus at distal end, risking damage to median nerve

BICEPS TENDONITIS

- Inflammation of tendon of long head of biceps
- Tendon is susceptible to wear and tear as it moves back and forth within intertubercular groove.
- Degenerative wear is a common cause of shoulder pain.
- Inflammation is also caused by repetitive microtrauma, seen in certain sports such as tennis.

RUPTURE OF THE BICEPS BRACHII

- This produces "Popeye deformity" with muscle forming a ball in distal part of the anterior arm
- Tendon of long head has the highest rate of spontaneous rupture of any tendon in the body
- Rupture of the tendon on background of chronic tendonitis usually affects those older than 40
- Traumatic rupture may occur in younger individuals, but is rare

MEMORY AIDS

Cubital fossa (from medial to lateral):

Madeline:	**M**edian Nerve
Brown's:	**B**rachial Artery
Big:	**B**iceps tendon
Red:	**R**adial Nerve
Purse:	**P**osterior interosseous nerve

6.4 ELBOW AND FOREARM

Study Aims

At the end of your study, you should be able to:

- Identify the different parts and surface markings of the radius and ulna
- Describe the articulations of the elbow joint, its movements, and supporting ligaments
- Describe the distal radio-ulnar joint, its movements, and supporting ligaments
- Describe the organization of the deep fascia and compartments of the arm
- Know the origins, insertions, and actions of the major muscles of the forearm

GUIDE

BONES

Ulna

- Stabilizing bone of forearm
- Medial to and longer than radius
- Osteological features
  - Olecranon—projection of proximal posterior end
  - Coronoid process—projection from proximal anterior end
  - Trochlear notch—anterior surface of olecranon, articulates with trochlea of humerus
  - Radial notch—rounded concavity on lateral side of coronoid process for radial head
  - Ulnar tuberosity—inferior to coronoid process for attachment of brachialis muscle
  - Supinator crest—crest inferior to radial notch for attachment of supinator muscle
  - Supinator fossa—concavity between supinator crest and coronoid process, for attachment of supinator muscle
  - Body—thicker proximally, tapering distally
  - Head—at distal end
  - Styloid process—conical process from the head

Radius

- Lateral and shorter bone of forearm
- Osteological features
  - Head—at proximal end, concave for articulation with capitulum of humerus
  - Neck—constricted region between head and tuberosity
  - Radial tuberosity—oval protuberance below head and neck for attachment of biceps brachii
  - Body—convex laterally and enlarging distally
  - Styloid process—projection from lateral aspect of distal end of radius
  - Dorsal tubercle—dorsal projection at distal end between groves for tendon of extensor carpi radialis longus and brevis and tendon of extensor pollicis longus
  - Ulnar notch—concavity on medial side of distal end for head of ulna
- Radius and ulna connected by
  - Interosseous membrane
    - Separates forearm into anterior and posterior compartments
    - Provides attachment for deep muscles of forearm
    - Fibers slope downward from radius to ulna
    - Most tense when hand is in mid-prone position
    - Has gap distal to neck of radius for posterior interosseus vessels
  - Oblique cord
    - Crosses gap in interosseus membrane
    - Attaches neck of radius to ulnar tuberosity
  - Radio-ulnar joints—proximal and distal *(see below)*

ELBOW JOINT

- Compound synovial joint in which radius and ulna articulate with humerus
- Joint cavity continuous with radio-ulnar joint
- Fibrous capsule encloses all three articulations
- Humero-ulnar joint
  - Uniaxial, synovial hinge joint
  - Between trochlea of humerus and trochlear notch of ulna
- Humeroradial joint
  - Uniaxial, synovial hinge joint
  - Between capitulum of humerus and head of radius
- Blood supply to humero-ulnar and humeroradial joints: anastomoses around elbow from brachial, radial, and ulnar arteries
- Nerve supply to these joints: musculocutaneous, radial, and ulnar nerves
- Proximal radio-ulnar joint
  - Uniaxial, synovial pivot joint
  - Between head of radius and radial notch of ulna
  - Blood supply: anterior and posterior interosseous arteries
  - Nerve supply: musculocutaneous, median and ulnar nerves
- Ligaments reinforcing elbow joint
  - Ulnar collateral ligament: medial epicondyle to coronoid process and olecranon
  - Radial collateral ligament: lateral epicondyle to annular ligament
  - Annular ligament
    - Strong fibrous circle
    - From margins of radial notch of ulna
    - Encircles head of radius
    - Maintains position of radial head during pronation and supination
- Movements at elbow joint
  - Flexion (~180 degrees) and extension at humero-ulnar and humeroradial joints
  - Pronation and supination with rotation of the head of the radius within annular ligament at proximal radio-ulnar joint
- Distal radio-ulnar joint
  - Synovial pivot joint
  - Articulation between ulnar notch and articular facet of radius at its distal end
  - Fibrocartilaginous articular disc binds ends of radius and ulna and is strengthened by anterior and posterior ligaments.

  - Disc separates cavity of joint from cavity of wrist joint.
  - Pronation and supination: distal end of radius moves anteriorly and medially across ulna
  - Blood supply: anterior and posterior interosseous arteries
  - Nerve supply: posterior interosseous nerve
- Carrying angle
  - Angle between long axis of humerus and long axis of ulna with forearm fully extended and supinated in anatomical position
  - 10 to 15 degrees in males, more than 15 degrees in females *(figures are for deviations from 180 degrees)*
- Bursae *(important ones)*
  - Subcutaneous olecranon bursa: overlies olecranon in subcutaneous tissue
  - Subtendinous olecranon bursa: between olecranon and triceps tendon
  - Bicipitoradial bursa: between biceps tendon and anterior part of radial tuberosity

FASCIAL COMPARTMENTS OF FOREARM

- Forearm divided into anterior and posterior compartments by interosseous membrane
- Antebrachial fascia is thickened at distal end of radius.
  - Posteriorly forms extensor retinaculum
  - Anteriorly forms palmar carpal ligament
  - Also forms flexor retinaculum (transverse carpal ligament) distal and deeper to palmar carpal ligament
- Carpal tunnel formed between flexor retinaculum, running between tubercles of scaphoid and trapezium radially to pisiform and hook of hamate on ulnar side, and anterior concavity of carpus

MUSCLES OF THE FOREARM (LISTED FROM LATERAL TO MEDIAL)

- Anterior (flexor) compartment
  - Superficial group (origin at medial epicondyle)
    - Pronator teres (pronates forearm)
    - Flexor carpi radialis (flexes and abducts wrist)
    - Palmaris longus (absent in some individuals; tenses palmar aponeurosis)
    - Flexor carpi ulnaris (flexes and adducts wrist)
    - Flexor digitorum superficialis (flexes PIP joints via four tendons)

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Pronator teres	Two heads: medial epicondyle of humerus, coronoid process of ulna	Midway along lateral surface of radius	Median nerve (C6,C7)	Pronates forearm and assists with elbow flexion	Anterior ulnar recurrent artery
Flexor carpi radialis	Medial epicondyle of humerus	Base of 2nd metacarpal	Median nerve (C6,C7)	Flexes and abducts hand at wrist	Radial artery
Palmaris longus	Medial epicondyle of humerus	Distal half of flexor retinaculum and palmar aponeurosis	Median nerve (C7,C8)	Flexes hand and tenses palmar aponeurosis	Posterior ulnar recurrent artery
Flexor carpi ulnaris	*Humeral head*: medial epicondyle of humerus; *Ulnar head*: olecranon and posterior border of ulna	Pisiform bone, hook of hamate, base of 5th metacarpal	Ulnar nerve (C7,C8 and T1)	Flexes and adducts hand at wrist	Posterior ulnar recurrent artery
Flexor digitorum superficialis	*Humero-ulnar head:* medial epicondyle of humerus and coronoid process of ulna *Radial head:* superior half of anterior radius	Bodies of middle phalanges of medial four digits	Median nerve (C8–T1)	Flexes middle and proximal phalanges of medial four digits; also flexes hand at wrist	Ulnar and radial arteries

- Deep group
  - Flexor digitorum profundus (flexes at DIP joint)
  - Flexor pollicis longus (flexes thumb)
  - Pronator quadratus (pronates forearm)

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Deep					
Flexor digitorum profundus	Medial and anterior surface of proximal three-quarters of ulna, and interosseous membrane	Palmer base of distal phalanges of medial four digits	*Medial part*: ulnar nerve (C8–T1); *Lateral part*: medial nerve (C8–T1)	Flexes distal phalanges of medial four digits; assists in flexion of hand at wrist	Anterior interosseous artery and muscular branches of ulnar artery
Flexor pollicis longus	Anterior surface of radius and interosseous membrane	Palmar base of distal phalanx of thumb	Median nerve (anterior interosseous) (C7–8)	Flexes phalanges of thumb	Anterior interosseous artery
Pronator quadratus	Distal fourth of anterior ulna	Distal fourth of anterior radius	Median nerve (anterior interosseous) (C7–8)	Pronates forearm	Anterior interosseous artery

- Posterior (extensor) compartment
  - Superficial group (origin at lateral epicondyle)
    - Brachioradialis (flexes elbow)
    - Extensor carpi radialis longus and brevis (extend and abduct wrist)
    - Extensor digitorum (extends fingers)
    - Extensor digiti minimi (extends 5th digit)
    - Extensor carpi ulnaris (extends and adducts wrist)
    - Anconeus (extends elbow)

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Brachioradialis	Proximal two thirds of lateral supracondylar ridge of humerus	Lateral side of distal end of radius	Radial nerve (C5–C6)	Weak flexion of forearm when forearm is midpronated	Radial recurrent artery
Extensor carpi radialis longus	Distal one-third of lateral supracondylar ridge of humerus	Dorsal base of 2nd metacarpal and slip to 3rd metacarpal	Radial nerve (C6–C7)	Extends and abducts hand at wrist	Radial artery and radial recurrent artery
Extensor carpi radialis brevis	Lateral epicondyle of humerus (common extensor tendon)	Dorsal base of third metacarpal	Radial nerve (deep branch) (C7–C8)	Extends and abducts hand at wrist	Radial artery and radial recurrent artery
Extensor digitorum	Lateral epicondyle of humerus (common extensor tendon)	Extensor expansions of medial four digits	Posterior interosseous nerve (C7–C8)	Extends medial four digits; assists in wrist extension	Posterior interosseous artery
Extensor digiti minimi	Lateral epicondyle of humerus (common extensor tendon)	Extensor expansion of 5th digit	Radial nerve (posterior interosseous) (C7–C8)	Extends 5th digit	Posterior interosseous artery
Extensor carpi ulnaris	Lateral epicondyle of humerus and posterior border of ulna (common extensor tendon)	Dorsal base of 5th metacarpal	Radial nerve (posterior interosseous) (C7–C8)	Extends and abducts hand at wrist	Posterior interosseous artery
Anconeus	Posterior surface of lateral epicondyle of humerus	Lateral surface of olecranon and posterior proximal ulna	Radial nerve (C5–7)	Assists triceps in extending elbow; abducts ulna during pronation	Deep brachial artery

- Deep group (originate from shaft of radius, ulna, and interosseous membrane)
  - Supinator (supinates forearm)
  - Abductor pollicis longus (abducts thumb)
  - Extensor pollicis brevis and longus (extend thumb)
  - Extensor indicis (extend index finger)

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Supinator	Lateral epicondyle of humerus, supinator crest of ulna	Lateral, posterior and anterior surfaces of proximal third of radius	Radial nerve (deep branch) (C6–C7)	Supinates forearm	Radial recurrent and posterior interosseous arteries
Abductor pollicis longus	Posterior surface of ulna, radius, and interosseous membrane	Base of 1st metacarpal	Radial nerve (posterior interosseous) (C7–C8)	Abducts and extends thumb at carpometacarpal joint	Posterior interosseous artery
Extensor pollicis brevis	Posterior surface of radius and interosseous membrane	Dorsal base of proximal phalanx of thumb	Radial nerve (posterior interosseous) (C7–C8)	Extends proximal phalanx of thumb at carpometacarpal joint	Posterior interosseous artery
Extensor pollicis longus	Posterior surface of middle third of ulna, interosseous membrane	Dorsal base of distal phalanx of thumb	Radial nerve (posterior interosseous) (C7–C8)	Extends distal phalanx of thumb at interphalangeal and metacarpophalangeal joints	Posterior interosseous artery
Extensor indicis	Posterior surface of ulna, interosseous membrane	Extensor expansion of 2nd digit	Radial nerve (posterior interosseous) (C7–C8)	Extend 2nd digit and helps extend hand at wrist	Posterior interosseous artery

CLINICAL POINTS

SUBLUXATION OF RADIAL HEAD *(NURSEMAID ELBOW)*

- Caused by sudden pulling on the upper limb with the forearm pronated
- Distal attachment of the annular ligament is torn and radial head slips out, trapping the ligament between it and the capitulum.
- Preschool children, especially girls, are most vulnerable.
- Head of radius is repositioned by supinating forearm fully and then flexing elbow.

BURSITIS OF THE ELBOW

- Repeated pressure or friction on a bursa may cause it to become inflamed and tender.
- Subcutaneous olecranon bursitis *("student's elbow")* is most common, often occurring in students (from resting elbows on desk), darts players, and from falls and abrasions to the elbow.
- Subtendinous olecranon bursitis is less common, as is bicipitoradial bursitis.

EPICONDYLITIS

- Activities involving repetitive movements of wrist may lead to localized elbow pain.
- Repeated extension of wrist causes lateral epicondylitis *("tennis elbow")*—microtrauma of common extensor muscle origin, with pain felt over the lateral aspect of the elbow.
- Medial epicondylitis *("golfer's elbow")* results from repeated wrist flexion, with pain felt over the medial epicondyle, especially on resisted wrist flexion
- Bursitis or synovitis may coexist with epicondylitis.

MEMORY AIDS

Radial nerve innervates the **BEST**!
Brachioradialis
Extensors
Supinator
Triceps

Muscles that flex the elbow:
Three B's Bend the el**B**ow
Brachialis **B**iceps
Brachioradialis

6.5 WRIST AND HAND

Study Aims

At the end of your study, you should be able to:

- Describe the radiocarpal joint, its movements, and supporting ligaments
- Know the bones of the hand and their organization
- Describe the movements at the carpometacarpal, metacarpophalangeal, and interphalangeal joints
- Describe the organization of the deep fascia of the hand
- Understand the arrangement of the intrinsic muscles of the hand

GUIDE

WRIST (RADIOCARPAL) JOINT

- Biaxial synovial joint
  - Located at a line joining styloid processes of radius and ulna
  - Articulation of distal end of radius and articular disc of radio-ulnar joint with proximal row of carpal bones (except the pisiform)
  - Fibrous capsule surrounds wrist
    - From distal ends of radius and ulna to proximal row of carpal bones
    - Lined by synovial membrane with numerous folds
  - Movements
    - Flexion/extension
    - Abduction/adduction (radial/ulnar abduction)
    - Circumduction
    - Adduction greater than adduction
  - Ligaments
    - Dorsal and palmar radiocarpal ligaments from radius to the two rows of carpals on palmar and dorsal sides
    - Ulnar collateral ligament from ulnar styloid process to triquetrum
    - Radial styloid ligament from radial styloid process to scaphoid
  - Blood supply: branches of the dorsal and palmar carpal arches
  - Nerve supply
    - Anterior interosseous branch of median nerve
    - Posterior interosseous branch of radial nerve
    - Dorsal and deep branches of ulnar nerve

HAND

Bones (27).

- Carpal bones (bones of wrist or carpus—8)
  - Proximal row: scaphoid, lunate, triquetrum, pisiform,
  - Distal row: trapezium, trapezoid, capitate, hamate
- Metacarpals (5)
  - Base (proximal)—articulate with distal row of carpal bones
  - Body
  - Head (distal)—articulate with proximal phalanges and form knuckles
- Phalanges (14)
  - Each digit has three phalanges: proximal, middle, and distal, except for
  - Thumb (has two)
  - Each phalanx has a base (proximal), body, and head (distal)
  - Decrease in size from proximal to distal

Major Joints of the Hand

- Carpometacarpal, metacarpophalangeal, and interphalangeal are all synovial joints supplied by branches of adjacent vessels and nerves.
- Intercarpal joints
  - Joints between carpal bones of first row and joints between carpal bones of second row
  - Midcarpal joint between first and second rows
  - Supported by anterior, posterior, and interosseous ligaments
  - Function as single unit
  - Small gliding movements between carpal bones
- Carpometacarpal joints
  - Plane type synovial joints, except for carpometacarpal of thumb (saddle type)
  - Medial four carpometacarpal joints in one fibrous joint capsule
  - Separate capsule for thumb
  - Joint for thumb between trapezium and 1st metacarpal
    - Allows flexion, extension, abduction, adduction, circumduction, and opposition
    - Loose joint capsule allows for free movement
- Metacarpophalangeal joints (MCP)
  - Heads of metacarpals articulate with base of proximal phalanx.
  - Deep transverse metacarpal ligaments hold together heads of 2nd through 5th metacarpals.
  - Separate joint capsule for each joint
  - Movements: flexion, extension, abduction, and adduction
  - Because collateral ligaments tighten during flexion, abduction and adduction are possible only in extended position.
- Interphalangeal joints
  - Proximal interphalangeal joint = PIP
  - Distal interphalangeal joint = DIP
  - Allow flexion and extension

Fascia of the Hand

- Extensor and flexor retinaculum continuous with antebrachial fascia
- Palmar fascia thickened centrally as palmar aponeurosis
  - Four distinct extensions to bases of fingers
  - Continuous with the fibrous tendon sheaths
  - Anchored tightly to skin of palm by numerous ligamentous bands (retinacula cutis)
- Fibrous digital sheaths surround synovial sheaths that enclose superficial and deep flexor tendons.
- Medial fibrous septum extends from medial border of palmar aponeurosis to 5th metacarpal.
- Lateral fibrous septum extends from lateral border of palmar aponeurosis to 3rd metacarpal.
- Septa create compartments within the palm

Muscles of the Hand

- Adductor pollicis
- Thenar (lateral) compartment
  - Abductor pollicis brevis
  - Flexor pollicis brevis
  - Opponens pollicis
- Hypothenar (medial) compartment
  - Abductor digiti minimi
  - Flexor digiti minimi brevis
  - Opponens digiti minimi
- Short muscles of hand
  - Lumbricals—unusual in that they flex MCP joints and extend IP joints
  - Palmar interossei—adduct digits
  - Dorsal interossei—abduct digits
- Palmaris brevis
  - Wrinkles skin of hypothenar eminence
  - Improves palmar grip

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Abductor pollicis brevis	Flexor retinaculum and tubercles of scaphoid and trapezium	Lateral side of base of proximal phalanx of thumb (1st digit)	Median nerve (recurrent branch) (C8–T1)	Abducts and assists in opposition of thumb	Superficial palmar branch of radial artery
Flexor pollicis brevis	Flexor retinaculum and tubercle of trapezium	Lateral side of base of proximal phalanx of thumb	Median nerve (recurrent branch) (C8–T1)	Flexes proximal phalanx of thumb	Superficial palmar branch of radial artery
Opponens pollicis	Flexor retinaculum and tubercle of trapezium	Lateral side of 1st metacarpal	Median nerve (recurrent branch) (C8–T1)	Draws 1st metacarpal forward and rotates it medially	Superficial palmar branch of radial artery
Adductor pollicis	*Oblique head*: bases of 2nd and 3rd metacarpals capitate and adjacent bones; *Transverse head*: anterior surface of 3rd metacarpal	Medial side of base of proximal phalanx of thumb	Ulnar nerve (deep branch) (C8–T1)	Adducts thumb	Deep palmar arch
Palmaris brevis	Palmar aponeurosis and flexor retinaculum	Skin of medial border of palm	Superficial palmar branch of ulnar nerve (C8)	Deepens hollow of hand, assists grip	Superficial palmar arch
Abductor digiti minimi (hand)	Pisiform bone, tendon of flexor carpi ulnaris	Medial side of base of proximal phalanx of little finger (5th digit)	Ulnar nerve (deep branch) (C8–T1)	Abducts the little finger (5th digit)	Deep palmar branch of ulnar artery
Flexor digiti minimi brevis (hand)	Flexor retinaculum and hook of hamate bone	Medial side of base of proximal phalanx of little finger	Ulnar nerve (deep branch) (C8–T1)	Flexes proximal phalanx of the little finger	Deep palmar branch of ulnar artery
Opponens digiti minimi	Flexor retinaculum and hook of hamate bone	Palmar surface of 5th metacarpal	Ulnar nerve (deep branch) (C8–T1)	Draws 5th metacarpal anteriorly and rotates it to face thumb	Deep palmar branch of ulnar artery
Lumbricals 1 and 2	Lateral two tendons of flexor digitorum profundus	Lateral sides of extensor expansion of digits 2 and 3	Median nerve (C8–T1)	Extends digits at interphalangeal joints and flexes metacarpophalangeal joints	Superficial and deep palmar arches
Lumbricals 3 and 4	Medial three tendons of flexor digitorum profundus	Lateral sides of extensor expansion of digits 4 and 5	Ulnar nerve (deep branch) (C8–T1)	Extends digits at interphalangeal joints and flexes metacarpophalangeal joints	Superficial and deep palmar arches
Dorsal interossei	Adjacent sides of two metacarpal bones	Base of proximal phalanx and extensor expansion of digits 2–4	Ulnar nerve (deep branch) (C8–T1)	Abducts digits from axial line of hand (3rd digit); flex digits at metacarpophalangeal joint and extend interphalangeal joints	Deep palmar arch
Palmar interossei	Palmar surfaces of metacarpals 2, 4, and 5	Bases of proximal phalanx and extensor expansion of digits 2, 4, and 5	Ulnar nerve (deep branch) (C8–T1)	Adducts digits toward axial line of hand (3rd digit); flexes digits at metacarpophalangeal joint and extends interphalangeal joints	Deep palmar arch

ANATOMICAL POINTS

ARTERIAL ARCHES OF THE HAND

- Superficial palmar arch
  - Formed from main terminal branch of ulnar artery
    - Enters hand between hook of hamate and pisiform bone
    - Superficial to flexor retinaculum
    - Divides into superficial palmar arch and deep branch of ulnar artery
  - Gives rise to three common palmar digital arteries
    - Anastomose with palmar metacarpal arteries
    - Gives rise to two proper palmar digital arteries to sides of digits 2 through 4
- Deep palmar arch
  - Formed from terminal branch of radial artery
    - Passes from anatomical snuff box on dorsum of hand
    - Runs between heads of 1st dorsal interosseus muscle to reach palm
  - Anastomoses with deep branch of ulnar artery
  - Gives off three palmar metacarpal arteries (anastomose with common palmar digital arteries from superficial arch)
  - Gives off princeps pollicis artery to supply palmar surface and lateral sides of thumb

ANATOMICAL SNUFF BOX

- Depression on posterolateral wrist
- Visible when thumb is fully extended
- Bounded anteriorly (on lateral side) by tendons of abductor pollicis longus and extensor pollicis brevis
- Bounded posteriorly (on medial side) by tendon of extensor pollicis longus
- Structures in floor of snuffbox
  - Radial artery
  - Radial styloid process proximally
  - Base of 1st metacarpal distally
  - Scaphoid and trapezium between radial styloid and 1st metacarpal

CLINICAL POINTS

COLLES' FRACTURE

- Complete transverse fracture within the distal 2 cm of the radius
- Distal fragment displaced dorsally, giving the classic "dinner fork deformity"
- Ulnar styloid may also be avulsed.
- Results from forced dorsiflexion of the hand, such as in breaking a fall with an outstretched, pronated hand
- Most common fracture in adults older than 50 years old
- Seen most frequently in elderly women
- Healing usually good as the bone has a rich blood supply

SCAPHOID FRACTURE

- Scaphoid is the most commonly fractured bone of the carpus.
- Proximal pole of the bone has a poor blood suppl, and as a result, fracture may take several months to heal.
- This increases risk of avascular necrosis and subsequent degenerative joint disease at the wrist.
- Fracture often difficult to spot on initial radiographs, which should be repeated at 2 to 3 weeks in any patient presenting with a severely sprained wrist.

DUPUYTREN'S CONTRACTURE

- Progressive fibronodular thickening of the palmar fascia
- Leads to fixed flexion deformity of the fingers (most commonly the 4th and 5th digits)
- Condition often bilateral and usually affects middle-aged males of Northern European decent, suggesting hereditary predisposition
- Risk factors include alcohol, liver disease, and antiepileptic medication.
- Treatment is surgical.

MEMORY AIDS

Carpal bones (lateral to medial): **S**ome **L**overs **T**ry **P**ositions **T**hat **T**hey **Ca**n't **H**andle
Proximal Row
Some: Scaphoid
Lovers: Lunate
Try: Triquetral
Positions: Pisiform
Distal Row
That: **T**rapezium ("Trapezium over the thumb")
They: **T**rapezoid
Can't: **C**apitate
Handle: **H**amate

Note: If you forget if you're starting at the lateral or medial side of each row, remember that the Scaphoid is in the anatomical snuffbox and the trapez **iUM** is at the base of the th **UMB**.

Flexor carpi superficialis and profundus insertions**: Superficialis splits the two, to permit profundus to pass through**
Interossei muscles: **P**almar interossei **AD**duct the digits **(PAD)**
Dorsal interossei **AB**duct the digits **(DAB)**

6.6 NEUROVASCULATURE

Study Aims

At the end of your study, you should be able to:

- Describe the arterial supply of the arm, forearm, and hand, distinguishing the arteries supplying each of the compartments
- Know the locations of the brachial, radial, and ulnar pulses
- Describe the venous drainage of the hand, forearm, and arm
- Describe the lymphatic drainage of the upper limb
- Understand the organization of the brachial plexus
- Know the innervation to the compartments of the arm and forearm
- Recognize the course of the major nerves of the upper limb
- Understand the dermatome map of the upper limb and its cutaneous innervation

GUIDE

VASCULAR SUPPLY TO THE UPPER LIMB

Arterial Supply to the Arm

Axillary Artery.
- Begins at lateral border of 1st rib and ends at inferior border of teres major
- Divided into three descriptive parts by pectoralis minor muscle
- First part
  - 1st rib to medial border of pectoralis minor
  - Enclosed in axillary sheath
  - One branch—superior thoracic artery supplying serratus anterior
- Second part
  - Posterior to pectoralis minor
  - Two branches
    - Thoraco-acromial artery
    - Lateral thoracic artery
    - Both supply pectoral muscles and breast.
- Third part
  - Lateral border of pectoralis minor to inferior border of teres major
  - Three branches
    - Subscapular artery: largest branch, divides into circumflex scapular and thoracodorsal arteries, supplies serratus anterior, teres major, subscapularis, and latissimus dorsi muscles
    - Anterior and posterior circumflex humeral arteries

Brachial Artery.
- Continuation of axillary artery, ends in cubital fossa
- Lies anterior to triceps and brachialis throughout its course
- Accompanied by median nerve, which crosses anterior to artery and lies medially in cubital fossa
- Divides into ulnar and radial arteries under bicipital aponeurosis
- Branches
  - Many muscular branches
  - Profunda brachii artery from medial aspect
  - Superior and inferior ulnar collateral branches

Profunda Brachii (Deep Artery of the Arm).
- Accompanies radial artery in radial groove
- Divides into anterior and posterior descending branches to elbow

Arterial Supply to the Forearm

Ulnar Artery.
- Larger of two terminal branches of brachial artery
- Begins medial to biceps tendon and descends through anterior compartment deep to pronator teres
- Branches
  - Anterior ulnar recurrent
  - Posterior ulnar recurrent
  - Common interosseus, which branches into
    - Anterior interosseus artery
    - Posterior interosseus artery
  - Muscular branches to muscles of medial side of forearm
  - Branches to the hand

Radial Artery.
- Begins in cubital fossa at neck of radius
- Passes distally deep to brachioradialis muscle
- Palpable throughout lateral forearm (best felt at wrist)
- Branches
  - Supplies flexor and extensor muscles on lateral side of forearm
  - Radial recurrent artery
  - Branches to hand

Arterial Supply to the Hand

Branches from the Ulnar Artery.
- Palmar carpal branch
  - Runs across anterior wrist deep to tendons of flexor digitorum profundus (FDP)
  - Anastomoses with palmar carpal branch of radial artery to form palmar carpal arch
- Dorsal carpal branch
  - Arises proximal to pisiform
  - Crosses dorsal to wrist
  - Anastomoses with dorsal carpal branch of radial artery to form dorsal carpal arch
- Superficial branch of ulnar artery in hand—continues into palm as superficial palmar arch
- Deep (palmar) branch of ulnar artery in the hand
  - Anastomoses with radial artery
  - Forms deep palmar arch

Venous Drainage of Hand and Forearm

- Veins of hand
  - Superficial and deep palmar venous arches
  - Dorsal venous network (arch)
  - Both drain to cephalic and basilic veins.
- Superficial veins of forearm
  - Basilic vein ascends posteromedially on forearm.
  - Cephalic vein ascends on lateral border of forearm.
  - Median cubital vein connects cephalic and basilic over cubital fossa.
- Deep veins of forearm
  - Paired radial and ulnar veins and interosseus veins accompany arteries of same name.
  - All communicate with superficial veins and median cubital vein.

Venous Drainage of Arm

Superficial Veins (Drain into Axillary Vein).
- Cephalic vein
  - On anterolateral surface
  - Enters groove between deltoid and pectoralis major (deltopectoral groove)
  - Then deltopectoral triangle
  - Empties into termination of axillary vein
- Basilic vein
  - Medial side, inferior arm
  - Pierces deep fascia at junction of inferior and middle third of arm
  - Runs superiorly to axillary vein

Deep Veins

- Paired, accompany brachial artery (venae comitantes)
- Form at elbow from radial and ulnar veins

- Have valves
- Merge with basilic vein to form axillary vein

Lymphatics

- All lymph from arm drains to axillary nodes
- Lymph from breasts and thorax also drains to nodes

INNERVATION TO UPPER LIMB

Brachial Plexus [C5–T1]

- Composed of
  - Roots (5)
  - Trunks (3)
  - Divisions (6)
  - Cords (3)
  - Branches (13+4 *from roots*)
- Roots
  - Ventral rami of spinal nerves C5–T1
  - Give rise to
    - Dorsal scapular nerve (C5, possible contribution from C4)
    - Long thoracic nerve (C5–C7) to serratus anterior muscle
- Trunks
  - Superior from ventral rami of C5 and 6
    - Branches: nerve to subclavius muscle; suprascapular nerve to supraspinatus and infraspinatus, shoulder joint
  - Middle from ventral ramus of C7
  - Inferior from ventral rami of C8 and T1
- Divisions
  - Anterior divisions of superior and middle trunks form lateral cord
  - Anterior division of inferior trunk continues as medial cord
  - Posterior divisions of all three trunks for posterior cord
- Cords
  - Named by relationship to axillary artery, which they surround
    - Lateral
    - Medial
    - Posterior
- Branches
  - Branches from lateral cord
    - Lateral pectoral nerve (C5–C7) to pectoralis major and minor muscles
    - Musculocutaneous (C5–C7)
    - Lateral root of median nerve (C6–C7)
  - Branches from medial cord
    - Medial pectoral nerve (C8–T1) to pectoralis minor and major
    - Ulnar nerve (C8–T1)
    - Medial brachial cutaneous nerve (C8–T1) supplies skin over medial surface of arm and proximal surface of forearm.
    - Medial antebrachial cutaneous nerve (C8–T1) to skin over medial forearm
    - Median root of median nerve (C8–T1)
  - Branches from the posterior cord
    - Upper subscapular nerve (C5–C6) to subscapularis
    - Lower subscapular nerve (C5–C6) to teres major and subscapularis
    - Thoracodorsal nerve (C6–C8) to latissimus dorsi
    - Axillary nerve (C5–C6) to teres minor and deltoid (ends as upper lateral brachial cutaneous nerve)
    - Radial nerve (C5–T1) supplies all extensors of upper limb and sensation to skin overlying extensor region, including hand.
- Other facts
  - Anterior divisions supply flexor parts of upper limb.
  - Posterior divisions supply extensor parts of upper limb.
  - Each cord divides into two main terminal branches
    - Posterior → axillary and radial
    - Lateral → musculocutaneous and median
    - Medial → median and ulnar
  - Supraclavicular part of plexus
    - Arises from roots and trunks
    - Approachable through posterior triangle of neck
    - Dorsal scapular nerve
    - Nerve to subclavius
    - Suprascapular nerve
    - Long thoracic nerve
  - Infraclavicular part (cords and their branches) is in axilla
    - Arises from cords
    - Approachable through axilla
    - Rest of nerve branches from brachial plexus
  - Ulnar nerve supplies
    - Flexor carpi ulnaris
    - Medial half of flexor digitorum profundus (FDP)
    - Hypothenar muscles
    - 3rd and 4th lumbricals
    - All interossei muscles
    - Skin over medial hand and 1½ digits
  - Median nerve supplies
    - Forearm flexors (except flexor carpi ulnaris and lateral half of flexor digitorum profundus)
    - Thenar muscles and 1st and 2nd lumbricals
    - Skin over lateral hand and 3½ digits
  - Musculocutaneous nerve supplies
    - Flexor muscles of arm (anterior compartment)
    - Skin over lateral aspect of forearm (lateral antebrachial cutaneous)
  - Radial nerve supplies
    - Triceps
    - Anconeus
    - Extensor muscles of forearm
    - Skin over posterior arm and forearm
  - Axillary nerve supplies
    - Teres minor
    - Deltoid
    - Shoulder joint
    - Skin over inferior deltoid

Dermatomes and Cutaneous Innervation of the Upper Limb

- Dermatomes
  - Bandlike areas of skin
  - Each supplied by single spinal nerve through dorsal and ventral rami
  - Arranged in segmental fashion
- Cutaneous innervation of the upper limb
  - Follows segmental arrangement of spinal nerve contributions to brachial plexus

- No representation of C7 on anterior aspect of arm and forearm
- No representation of T1 on palmar or dorsal surface of hand

CLINICAL POINTS

BRACHIAL PLEXUS INJURY

- Disease, trauma, or excessive stretching (because of birth trauma) of the posterior triangle of the neck or axilla may damage brachial plexus.
- This results in paralysis and anesthesia in the distribution of the affected nerves.
- Various terms are used to describe the different lesions.
- *Erb's palsy* affects areas supplied by nerves from the superior part of the plexus.
- *Klumpke's palsy* affects areas supplied by nerves from the inferior part.

CARPAL TUNNEL SYNDROME

- Carpal tunnel syndrome results from compression of the median nerve as it passes under flexor retinaculum.
- Compression can be caused by any process that significantly reduces the size of the carpal tunnel: inflammation of the synovial sheaths, fluid retention, and infection.
- Pain or paraesthesia is felt in the lateral 3½ digits, may radiate toward the elbow, and is often worse at night.
- Also loss of sensation and diminished control of the median nerve–innervated muscles
- Surgical division of the flexor retinaculum may be necessary to relieve symptoms.

ULNAR NERVE INJURY

- Ulnar nerve may be compressed as it passes behind medial epicondyle of the humerus or through the Guyon canal at the wrist.
- Pain and/or paraesthesia is felt at medial aspect of the elbow radiating to the medial forearm and medial 1½ digits.
- Also may be weakness of the intrinsic muscles of the hand

RADIAL NERVE INJURY

- Palsy of the radial nerve is common after prolonged pressure on the back of the arm by resting it against a hard surface (such as back of movie theater seat—the "*Saturday night palsy*")
- Nerve may also be injured in fractures of humerus because it winds along spiral groove.
- Extensors of the wrist are paralyzed, resulting in a wrist drop.
- Triceps is not affected unless the nerve is injured proximally in the axilla.

MEMORY AIDS

Parts of the brachial plexus: **R**eally **T**hirsty? **D**rink **C**old **B**eer
Roots, **T**runks, **D**ivisions, **C**ords, **B**ranches

Terminal nerves of plexus: **MARMU**
Musculocutaneous, **A**xillary, **R**adial, **M**edian, **U**lnar

Muscles supplied by median nerve supply in hand: **LOAF**
Lumbricals (lateral), **O**pponens pollicis, **A**bductor pollicis brevis, **F**lexor pollicis brevis

Branches of brachial plexus medial cord: **M**oney **M**akes **M**any **M**en **U**nhappy
Medial pectoral nerve
Medial branch of median nerve
Medial cutaneous nerve of arm
Medial cutaneous nerve of forearm
Ulnar nerve

7 Lower Limb Study Guide

7.1 TOPOGRAPHIC ANATOMY

Study Aims

At the end of your study, you should be able to:

- Identify the bony landmarks of the lower limb
- Identify the main muscle masses and palpable tendons of the lower limb
- Identify the course of the great saphenous vein
- Identify the inguinal ligament and know its attachments
- Identify the popliteal fossa

GUIDE

BONY LANDMARKS

- Greater trochanter of femur
  - Posterior edge palpable on lateral side of thigh
  - 10 cm below iliac crest
  - Site of attachment of several gluteal muscles
- Lateral and medial femoral condyles palpable on lateral and medial aspects of knee
- Patella (kneecap)
  - Sesamoid bone
  - Within tendon of quadriceps femoris
  - Tendon continues as patellar ligament inferiorly
  - Lateral and medial margins palpable when knee is flexed
- Tibial condyles—medial and lateral rounded projections at its proximal end
- Tibial tuberosity
  - Elevation on anterior surface of tibia
  - Located between the two condyles
- Anterior border of tibia
  - Sharp and subcutaneous
  - Can be palpated from tibial tuberosity to medial malleolus
- Head of fibula
  - Subcutaneous
  - Can be palpated on posterolateral knee at level of tibial tuberosity
- Medial malleolus—medial projection of tibia at its distal end
- Lateral malleolus—expanded distal end of fibula
- Tuberosity of 5th metatarsal
  - Bony protuberance halfway along lateral side of foot
  - Site of attachment for fibularis brevis muscle

MUSCLES AND TENDONS

- Quadriceps femoris—muscle mass of anterior thigh *(see Section 7.2, Lower Limb: Hip and Thigh)*
- Gastrocnemius muscle—muscle mass of posterior leg *(see Section 7.4, Lower Limb: Leg)*
- Hamstring muscles
  - Palpable as a mass arising from ischial tuberosity
  - Palpable as medial and lateral superior borders of popliteal fossa
- Calcaneal tendon (Achilles tendon)
  - Tendon of gastrocnemius
  - Descends to calcaneus (heel) on posteroinferior leg, between medial and lateral malleoli
- Tendon of fibularis brevis—palpable at its attachment of base of 5th metatarsal
- Tendons of extensor hallucis longus and extensor digitorum longus—visible when toes are forcibly extended

VESSELS

- Great saphenous vein *(see Section 7, Neurovasculature)*
  - Descends along medial thigh and leg, passing posterior to knee
  - Visible with its tributaries when dilated and varicosed (because of incompetence of valves of vein to prevent backflow of blood)

OTHER PALPABLE LANDMARKS

- Inguinal ligament
  - Runs inferomedially from ASIS to pubic tubercle of pelvis
  - Folded inferior edge of external abdominal aponeurosis
  - Fold separates abdominal region from thigh
- Popliteal fossa *(see Section 7.3, Lower Limb: Knee)*
  - Diamond-shaped depression posterior to knee
  - Contains arteries, veins, and nerves of leg

ANATOMICAL POINTS

FUNCTIONAL OVERVIEW OF THE LOWER LIMB

The lower limb supports the body weight and permits locomotion. It is firmly attached through the rigid pelvis to the vertebral column. The joints are relatively stable and influenced by the line of gravity; this line passes posterior to the hip joint, anterior to the knee, and anterior to the ankle. Thus only the calf muscles need to contract to maintain an upright posture. Clinically the limb is divided into four compartments: gluteal, thigh, leg, and foot.

LOWER LIMB DEVELOPMENT

The general plan of the lower limb is similar to the upper limb; however, during development the lower limb undergoes medial rotation, bringing the extensors of the knee, ankle, and toes anteriorly with the knee pointing forward. The hip is unaffected, so hip flexors remain anterior and the extensors posterior.

CLINICAL POINTS

VARICOSE VEINS

- Dilated superficial veins most commonly seen in the posteromedial parts of the lower limb
- Result from absent or faulty valves in the communicating veins between the deep and superficial venous systems of the limb
- Secondary failure of the saphenofemoral valve may occur.
- Stagnation of blood in these vessels predisposes to thrombosis and subsequent inflammation (*thrombophlebitis*).

7.2 HIP AND THIGH

Study Aims

At the end of your study, you should be able to:

- Describe the structure of the hip joint and its movements
- Identify the different parts and surface markings of the femur
- Know the origins, insertions, and actions of the major muscles of the gluteal region
- Know the origins, insertions, and actions of the major muscles of the anterior, medial, and posterior thigh
- Identify the margins of the femoral triangle and describe its contents
- Describe the course of the adductor canal

GUIDE

HIP JOINT

- Multiaxial, ball-and-socket synovial joint
- Movements
  - Flexion 140 degrees
  - Extension 10 degrees
  - Abduction 45 degrees
  - Adduction 30 degrees
  - Internal rotation 40 degrees
  - External rotation 50 degrees
- Acetabulum *(see Section 5-2, Bones and Ligaments)*
  - Head of femur fits within
  - Composed of contributions from ilium, ischium, pubis
  - Deepened by incomplete ring of fibrocartilaginous labrum, which is attached to bony rim
  - Ring completed by transverse acetabular ligament, which spans acetabular notch
- Head of femur
  - Has ligamentum teres (ligament of head of femur)
    - Attaches fovea (pit) in head of femur to transverse acetabular ligament
    - Contains branch from obturator artery
- Capsule
  - Strong, fibrous, and loose
  - Attaches to acetabular labrum, transverse acetabular ligament, intertrochanteric line of femur
  - Lower third of neck of femur is extracapsular.
  - Strengthened by ligaments
    - Iliofemoral *(Y-shaped)*
    - Pubofemoral
    - Ischiofemoral ligaments
- Blood supply *(see Section 7.6, Lower Limb: Neurovasculature)*
  - Medial and lateral circumflex arteries from deep branch of femoral or femoral artery
  - Artery of head of femur (minor contribution)
- Nerve supply
  - Femoral nerve
  - Nerve to quadratus femoris (posteriorly)
  - Articular branch of sciatic nerve
  - Anterior division of obturator nerve (inferiorly)
  - Superior gluteal nerve (posteriorly)

FEMUR

Longest and heaviest bone in body

- Osteological features
  - Head with fovea (pit)
  - Neck—between head and shaft
  - Greater trochanter—large, lateral, posterosuperior projection from junction of neck and body
  - Lesser trochanter—rounded medial projection from junction of neck and body
  - Intertrochanteric line
    - Ridge running between greater and lesser trochanters
    - Indicates where neck joins body
  - Body (shaft)
    - Smooth and cylindrical
    - Wide, roughened line posterior: linea aspera
      - Runs vertically
      - Medial and lateral lips (margins)
    - Medial and lateral condyles—medial and lateral rounded projections at its proximal end
    - Medial and lateral epicondyles—central projection from each condyle

Neck is angled at 115 to 140 degrees (average 126 degrees) relative to long axis of shaft

Ligaments of the Hip Joint

Ligament	Attachments	Function
Iliofemoral	ASIS and acetabulum → intertrochanteric line (strong, Y-shaped ligament)	Prevents hyperextension
Ischiofemoral	Acetabular rim → circles superiorly and laterally to medial base of greater trochanter	Prevents hyperextension Screws femoral head into acetabulum
Pubofemoral	Pubic ramus → laterally and inferiorly to joint capsule	Tightens during extension and abduction Limits abduction
Transverse acetabular	Joins inferior ends of labrum, crosses acetabular notch	Completes the acetabular ring
Ligament of head of femur	Acetabular notch → fovea of femur (intracapsular but extrasynovial)	Contains artery to head of femur (minute in adults)

FASCIAL COMPARTMENTS OF THE THIGH

- Superficial fascia
  - Contains variable amounts of fat
  - Cutaneous nerves, such as saphenous and sural
  - Superficial veins, such as great and small saphenous
  - Lymphatics
- Deep fascia = fascia lata
  - Separates subcutaneous tissue from muscles
  - Dense strong layer
  - Prevents bulging of muscles during contraction, which improves efficiency of pumping blood through veins back to the heart
  - Attaches to inguinal ligament, iliac crests, and sacrum superiorly and is continuous with crural fascia inferiorly *(see Section 7.4, Lower Limb: Leg)*
- Fascial septa from fascia lata divide thigh into three compartments: anterior, medial, and posterior
- Iliotibial tract
  - Lateral thickening of fascia lata
  - Conjoint aponeurosis of tensor fasciae lata and gluteus maximus muscles
  - Attaches to tubercle on lateral condyle of tibia (Gerdy tubercle)
- Saphenous opening in fascia lata
  - Deficiency inferior to medial inguinal ligament
  - Spanned by cribriform fascia
  - Saphenous vein and efferent lymphatic vessels form superficial inguinal nodes, pass through opening and cribriform fascia

MUSCLES OF THE GLUTEAL REGION

- Extensor of hip: gluteus maximus
  - Also laterally rotates hip
  - Through iliotibial tract, extends knee
- Abductors of hip
  - Gluteus medius
  - Gluteus minimus
  - Most important function of these muscles: contract to prevent sagging of unsupported side of hip during locomotion, enabling opposite foot to swing through *(e.g., Trendelenburg test)*
- Lateral rotators of hip
  - Gluteus maximus
  - Piriformis
  - Obturator internus
  - Obturator externus
  - Gemelli (superior and inferior)
  - Quadratus femoris
- Extensors of knee
  - Gluteus maximus
  - Tensor fasciae latae

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Gluteus maximus	Ilium posterior to posterior gluteal line, dorsal surface of sacrum and coccyx, sacrotuberous ligament	Most fibers end in iliotibial tract that inserts into lateral condyle of tibia; some fibers insert into gluteal tuberosity of femur	Inferior gluteal nerve (L5–S2)	Extends flexed thigh, assists in lateral rotation, and abducts thigh	Inferior gluteal arteries mainly, and superior gluteal arteries occasionally
Gluteus medius	Lateral surface of ilium between anterior and posterior gluteal lines	Lateral surface of greater trochanter of femur	Superior gluteal nerve (L4–S1)	Abducts and medially rotates thigh at hips; steadies pelvis on leg when opposite leg is raised	Deep branch of superior gluteal artery

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Gluteus minimus	Lateral surface of ilium between anterior and inferior gluteal lines	Anterior surface of greater trochanter of femur	Superior gluteal nerve (L4–S1)	Abducts and medially rotates thigh at hips; steadies pelvis on leg when opposite leg is raised	Main trunk and deep branch of superior gluteal artery
Piriformis	Anterior surface of sacral segments 2–4, sacrotuberous ligament	Superior border of greater trochanter of femur	Ventral rami of upper L5, S1, S2	Laterally rotates extended thigh, abducts flexed thigh at hip	Superior and inferior gluteal arteries, internal pudendal artery
Obturator internus	Pelvic surface of obturator membrane and surrounding bone	Medial surface of greater trochanter of femur	Nerve to obturator internus (L5–S2)	Laterally rotates extended thigh, abducts flexed thigh at hip	Internal pudendal and obturator arteries
Superior gemellus	Outer surface of ischial spine	Medial surface of greater trochanter of femur	Nerve to obturator internus (L5–S2)	Laterally rotates extended thigh at the hip	Inferior gluteal and internal pudendal arteries
Inferior gemellus	Upper margin of ischial tuberosity	Medial surface of greater trochanter of femur	Nerve to quadratus femoris (L4–S1)	Laterally rotates extended thigh at the hip	Medial circumflex femoral artery
Quadratus femoris	Lateral margin of ischial tuberosity	Quadrate tubercle on intertrochanteric crest of femur	Nerve to quadratus femoris (L4–S1)	Laterally rotates thigh at hip	Medial circumflex femoral artery

MUSCLES OF THE THIGH

- Anterior (= extensor) compartment
  - Flexors of hip
    - Sartorius (also abducts and laterally rotates hip and flexes and medially rotates knee)
    - Iliopsoas
    - Pectineus (also adducts hip)
  - Extensor of knee: quadriceps femoris, composed of
    - Rectus femoris (also flexes hip)
    - Vastus lateralis
    - Vastus intermedius
    - Vastus medialis (also stabilizes patella)

Anterior Thigh Muscles

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Iliopsoas/ psoas major	Sides of vertebra T12 to L5 and transverse processes of L1–L5	Lesser trochanter of femur	Ventral rami of lumbar spinal nerves 1–3	Flexes thigh at hip and stabilizes the hip	Lumbar branches of iliolumbar artery
Iliacus	Superior 2/3 of iliac fossa, ala of sacrum, and anterior sacro-iliac ligaments	Lesser trochanter of femur and shaft inferior to it, to psoas major tendon	Femoral nerve (L2–L3)	Flexes thigh at hips and stabilizes hip joint, acts with psoas major	Iliac branches of iliolumbar artery
Tensor fasciae latae	Anterior superior iliac spine and anterior part of iliac crest	Iliotibial tract that attaches to lateral condyle of tibia	Superior gluteal nerve (L4–L5)	Abducts, medially rotates, and flexes thigh at hip; helps to keep knee extended	Ascending branch of lateral circumflex femoral artery
Sartorius	Anterior superior iliac spine and superior part of notch below it	Superior part of medial surface of tibia	Femoral nerve (L2–L3)	Abducts, laterally rotates, and flexes thigh; flexes knee joint	Femoral artery

Continued

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Quadratus femoris	Lateral margin of ischial tuberosity	Quadrate tubercle on intertrochanteric crest of femur	Nerve to quadratus femoris (L4 to S1)	Laterally rotates thigh at hip	Medial circumflex femoral artery
Rectus femoris	Anterior inferior iliac spine and ilium superior to acetabulum	Base of patella and to tibial tuberosity via patellar ligament	Femoral nerve (L2–L4)	Extends leg at knee joint and flexes thigh at hip joint	Profunda femoris and lateral circumflex femoral arteries
Vastus lateralis	Greater trochanter, lateral lip of linea aspera of femur	Base of patella and to tibial tuberosity via patellar ligament	Femoral nerve (L2–L4)	Extends leg at knee joint	Lateral circumflex femoral and profunda femoris arteries
Vastus medialis	Intertrochanteric line, medial lip of linea aspera of femur	Base of patella and to tibial tuberosity via patellar ligament	Femoral nerve (L2–L4)	Extends leg at knee joint	Femoral and profunda femoris arteries
Vastus intermedius	Anterior and lateral surfaces of body of femur	Base of patella and to tibial tuberosity via patellar ligament	Femoral nerve (L2–L4)	Extends leg at knee joint	Lateral circumflex femoral and profunda femoris arteries
Pectineus	Superior ramus of Pubis	Pectineal line of femur	Femoral nerve (L2–L3) and sometimes obturator nerve	Adducts and flexes thigh at hip	Medial circumflex femoral artery, obturator artery

- Medial (= adductor) compartment
  - Adductors of hip
    - Adductors longus
    - Adductor brevis
    - Adductor magnus (also assists in lateral rotation of knee)
    - Gracilis (also flexes knee)
  - Obturator externus—laterally rotates hip

Medial Thigh Muscles

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Adductor longus	Body of pubis, inferior to pubic crest	Middle third of linea aspera of femur	Obturator nerve (anterior division) (L2–L4)	Adducts thigh at hip	Profunda femoris and medial circumflex femoral arteries
Adductor brevis	Body and inferior pubic ramus	Pectineal line and proximal part of linea aspera of femur	Obturator nerve (L2–L4)	Adducts thigh at hip, weak hip flexor	Profunda femoris, medial circumflex femoral, and obturator arteries
Adductor magnus	Inferior pubic ramus, ramus of ischium Hamstring part: sciatic nerve (tibial division)	Gluteal tuberosity, linea aspera, supracondylar line; Hamstring part: adductor tubercle of femur	*Adductor part*: obturator nerve (L2–L4) *Hamstring part*: tibial nerve (L4)	*Adductor part*: adducts and flexes thigh; *Hamstring part*: extends thigh	Femoral, profunda femoris, and obturator arteries
Gracilis	Body and inferior ramus of pubis	Superior part of medial surface of tibia	Obturator nerve (L2–L3)	Adducts thigh, flexes and medially rotates leg	Profunda femoris artery, medial circumflex femoral artery
Obturator externus	Margins of obturator foramen, obturator membrane	Trochanteric fossa of femur	Obturator nerve (L2–L3)	Laterally rotates thigh, stabilizes head of femur in acetabulum	Medial circumflex femoral artery, obturator artery

- Posterior (= flexor) compartment
  - Hamstrings
  - Biceps femoris—also laterally rotates knee
    - Semitendinosus—also medially rotates knee
    - Semimembranosus—also medially rotates knee
    - Together extend hip (except short head of biceps femoris) and flex knee
  - Hamstring part of adductor magnus—extends hip

Posterior Thigh Muscles

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Semitendinosus	Upper and medial ischial tuberosity	Superior part of medial surface of tibia	Tibial division of sciatic nerve (L5–S2)	Flexes leg, extends thigh	Perforating branch of profunda femoris and medial circumflex femoral arteries
Semimembranosus	Upper and lateral ischial tuberosity	Posterior part of medial condyle of tibia	Tibial division of sciatic nerve (L5–S2)	Flexes leg, extends thigh	Perforating branch of profunda femoris and medial circumflex femoral arteries
Biceps femoris	*Long head:* ischial tuberosity *Short head*: linea aspera and lateral supracondylar line of femur	Lateral side of head of fibula	*Long head*: sciatic nerve (tibial division) (L5–S2) *Short head:* sciatic nerve (common fibular division)	Flexes and laterally rotates leg, extends thigh at hip	Perforating branches of profunda femoris, inferior gluteal, and medial circumflex femoral arteries

FEMORAL TRIANGLE

- Boundaries
  - Superior: inguinal ligament
  - Medial: medial border of adductor longus
  - Lateral: medial border of sartorius
- Contents
  - Femoral nerve (descends outside of femoral sheath)
  - Femoral sheath
    - About 4 cm long, extending below inguinal ligament
    - Subdivided into three compartments
      - *Lateral* contains femoral artery.
      - *Intermediate* contains femoral vein.
      - *Medial* is femoral canal.
  - Femoral canal
    - Potential space about 1.5 cm long
    - Contains loose connective tissue, lymphatic vessels, a deep inguinal lymph node (of Cloquet)
    - Femoral ring: abdominal entrance to femoral canal, closed by fatty tissue and parental peritoneum
  - Beyond extent of sheath
    - Femoral artery and branches
    - Femoral vein and tributaries

ADDUCTOR CANAL (= SUBSARTORIAL CANAL/ HUNTER'S CANAL)

- Boundaries
  - Superior: commences at apex of femoral triangle
  - Posterior: adductors longus and magnus
  - Anteromedial: sartorius and fascia
  - Anterolateral: vastus medialis
  - Inferior: terminates at adductor hiatus (in tendon of adductor magnus)
- Contents
  - Femoral artery and femoral vein
    - Pass through adductor hiatus
    - Become popliteal artery and vein when they enter popliteal fossa
  - Nerves
    - Saphenous nerve
    - Nerve to vastus medialis
  - Lymphatics

ANATOMICAL POINTS

HIP JOINT

The hip joint is a stable ball-and-socket joint that carries the whole body weight. Its stability results from the snug fit of the large femoral head and deep acetabulum, which is supported on all sides by powerful intrinsic ligaments and muscles. There is a tendency for the trunk to tilt backwards at the hip joints, because the line of gravity passes posteriorly; the powerful iliofemoral ligament resists this.

CLINICAL POINTS

FEMORAL HERNIA

- Hernia occurs when part of an abdominal viscus or fat protrudes into the femoral canal through its opening, the femoral ring.
- More common in women because of wider femoral ring
- Present as a mass (often tender) inferolateral to the pubic tubercle
- May enlarge by passing through the saphenous opening
- Are at a high risk of strangulation because of hard margins of femoral ring
- Surgical reduction and repair is usually necessary.

FRACTURED NECK OF FEMUR ("BROKEN HIP")

- Common in the elderly, particularly women with osteoporotic bone
- Can occur as the result of high-impact accident, such as head-on car collision
- May damage branches of medial circumflex femoral artery supplying the femoral head
- Results in bleeding into the hip joint and avascular necrosis of the head of the femur

MEMORY AIDS

Femoral triangle boundaries: **S**o **I** **M**ay **A**lways **L**ove **S**ally
Superiorly—**I**nguinal ligament, **M**edially—**A**dductor longus, **L**aterally—**S**artorius

Contents entering the femoral triangle (lateral to medial) as they pass under the inguinal ligament): **NAVEL**
Nerve*
Artery
Vein
Empty space**
Lacunar ligament***

7.3 KNEE

Study Aims

At the end of your study, you should be able to:

- Understand the movements of the knee joint
- Describe the attachments and functions of the ligaments strengthening the joint
- Identify the major bursae surrounding the knee and understand their function
- Identify the margins of the popliteal fossa and describe its contents

GUIDE

KNEE JOINT

- Biaxial, hinge-type synovial joint
- Movements
  - Flexion and extension
  - Some gliding and rolling
  - Some medial and lateral rotation about vertical axis
- Articular capsule—thin and weak, offers little support in itself
- Fibrous capsule
  - Strong
  - Attaches to femur superior to condyles
  - Attaches to articular margin of tibia
  - Deficient superiorly on lateral tibial condyle, to allow passage of popliteus tendon
  - Deficient inferiorly where tendon of popliteus crosses
- Blood supply
  - Genicular branches of the femoral and popliteal arteries
    - Lateral and medial superior genicular
    - Middle genicular
    - Lateral and medial inferior genicular
  - Anterior tibial recurrent → anterior and posterior recurrent arteries
  - Circumflex fibular artery → anterior and posterior recurrent arteries
  - Arteries form genicular anastomosis around the knee
- Nerve supply *(see Section 7.2, Hip and Thigh)*
  - Obturator
  - Articular branches of femoral, tibial, and common fibular nerves

BONES ARTICULATING IN THE KNEE JOINT

- Lateral and medial articulations between femoral condyles and tibial condyles
- Smooth superior surface of tibia for articulation called tibial plateau
- Intermediate articulation between patella and femur
- Patella
  - Large sesamoid bone embedded in the quadriceps tendon
  - Articulation called patellofemoral joint

LIGAMENTS REINFORCING FIBROUS CAPSULE

- Extracapsular
  - Medial (tibial) collateral ligament
    - Flat and bandlike
    - Attached to medial meniscus on deep surface
  - Lateral (fibular) collateral ligament
    - Strong and cordlike
    - Separated by lateral meniscus by tendon of popliteus muscle
    - Splits tendon of biceps
    - Prior to its insertion
  - Patellar ligament
  - Oblique popliteal ligament
  - Arcuate popliteal ligament
- Intracapsular
  - Anterior cruciate ligament
    - Extends from posterior medial side of lateral femoral condyle to anterior intercondylar area of tibia
    - Taut when knee is fully extended
    - Prevents posterior displacement of femur on tibia and hyperextension of joint
    - Intracapsular but extrasynovial
  - Posterior cruciate ligament
    - Stronger of two cruciate ligaments
    - Extends from lateral surface of medial condyle of femur to posterior intercondylar region of tibia
    - Taut during flexion
    - Prevents anterior displacement of femur on tibia

*Femoral, but it does not descend with the femoral artery and vein in the femoral sheath. It travels on the surface of the iliopsoas muscle. The femoral branch of the genitofemoral nerve travels beneath the inguinal ligament just lateral to the femoral artery, within the femoral sheath.

**Femoral canal, because it is a potential space filled with compressible tissue.

***The hard medial margin of the femoral ring. It is an expansion of the inguinal ligament, filling the gap between the attachment of the inguinal ligament to the pubic tubercle and the pecten pubis, posteriorly.

- Medial and lateral menisci
  - Crescentic plates of fibrocartilage
  - Wedge-shaped to deepen articulating surface of tibia
  - Function as "shock absorbers"
  - Transverse ligament of knee joints anterior surfaces of menisci
  - Medial meniscus
    - C-shaped
    - Adherent to tibial collateral ligament
  - Lateral meniscus
    - O-shaped
    - Joined to posterior cruciate ligament and medial femoral condyle by posterior meniscofemoral ligament

Ligaments of the Knee Joint

Ligament	Attachments	Function
Extracapsular Ligaments		
Patellar	Patella → tibial tuberosity	Continuation of quadriceps tendon
Tibial collateral	Medial femoral epicondyle → medial tibial condyle (and meniscus)	Limits extension Limits abduction
Fibular collateral	Lateral femoral epicondyle → fibular head	Limits extension Limits adduction
Arcuate popliteal	Fibular head → capsule	Limits medial rotation
Oblique popliteal	Lateral femur → posterior tibia	Limits hyperextension
Intracapsular Ligaments		
Anterior cruciate (extrasynovial)	Lateral femoral condyle → anterior intercondylar tibia	Prevents posterior slipping of femur on tibia (Torn in hyperextension)
Posterior cruciate (extrasynovial)	Medial femoral condyle → posterior intercondylar tibia	Prevents anterior slipping of femur on tibia
Transverse	Anterior edges of menisci	Stabilizes menisci
Posterior meniscofemoral	Posterior of lateral meniscus → medial femoral condyle	Stabilizes lateral meniscus

BURSAE AROUND THE KNEE JOINT

- Many (12+) bursae surround the knee.
  - Facilitate movement of tendons and skin over joint during flexion or extension
  - Needed because most tendons pull vertically across joint
- Four bursae communicate with synovial cavity of the knee
  - Suprapatellar
  - Popliteus
  - Anserine
  - Gastrocnemius bursae
- Suprapatellar bursa
  - Particularly vulnerable to infection following penetrating trauma
  - Allows spread of infection directly into knee joint

Main Bursae of the Knee

Bursa	Location
Suprapatellar	Between femur and quadriceps tendon
Popliteus	Between lateral tibial condyle and popliteus tendon
Anserine	Between tibial collateral ligament and tendons of sartorius, gracilis, and semitendinosus
Gastrocnemius	Deep to proximal attachment of medial gastrocnemius head
Semimembranosus	Deep to tendon of semimembranosus
Semitendinosus	Deep to heads of gastrocnemius muscles
Prepatellar	Between skin and anterior surface of patella
Subcutaneous infrapatellar	Between skin and tibial tuberosity
Deep infrapatellar	Between tibia and patellar ligament

POPLITEAL FOSSA

- Boundaries
  - Superomedial: semitendinosus and semimembranosus
  - Superolateral: biceps femoris
  - Inferomedial and lateral: medial and lateral heads of gastrocnemius
  - Floor: popliteal surface of femur, oblique popliteal ligament, fascia over popliteus muscle
  - Roof: skin and fascia
- Contents
  - Small saphenous vein
  - Popliteal artery and veins *(deeper than nerves)*
  - Tibial nerve and common fibular nerve (from sciatic)
  - Posterior cutaneous nerve of thigh
  - Lymphatic vessels and nodes
  - Order of structures (lateral to medial): tibial nerve, vein, artery

CLINICAL POINTS

BAKER'S CYST

- Posterior herniation of the synovial membrane through the joint capsule into the popliteal fossa
- Swelling appears below joint line and may extend as far as the midcalf.
- Large swellings may interfere with knee movements but otherwise asymptomatic.

BURSITIS

- Inflammation of the bursa surrounding the knee because of repeated frictional forces.
- In chronic inflammation, bursae become distended and filled with fluid.
- Prepatellar bursitis (housemaid's knee) and infrapatellar bursitis (clergyman's knee) are most-recognized variants.

KNEE INJURY

- Knee injuries common, as the knee joint has little external supportive tissue.
- Ligament sprains usually self-limiting but may cause secondary damage to menisci.
- Tearing of the ligaments often needs surgical correction.
- Rupture of anterior cruciate ligament occurs when force is directed anteriorly to the semi-flexed knee, typically occurring in skiers and footballers.
- Posterior cruciate ligament is more resilient to injury but may rupture when force is applied to the tibial tuberosity while the knee is flexed.
- Collateral ligaments are vulnerable to lateral stresses.

MEMORY AIDS

Knock-knee and Bowleg: Genu valgum vs. Genu varum
Knock-knee: Genu valgum
Genu val**GUM**—knees are **GUM**med together
Bowleg: Genu varum
Genu **VAR**um—**VAR** rhymes with far—knees are **VAR** (far) apart

7.4 LEG

Study Aims

At the end of your study, you should be able to:

- Describe the fascial compartments of the leg and understand their importance
- Identify the different parts and surface markings of the tibia and fibula
- Know the origins, insertions, and actions of the muscles of the leg

GUIDE

BONES

- Tibia
  - Large, weightbearing
  - Osteological features
    - Medial and lateral condyles—medial and lateral protuberances at proximal end articulate with femur
    - Intercondylar eminence—together with condyles forms tibial plateau, fits into intercondylar fossa of femur
    - Tibial tuberosity—proximal end of anterior border, broad bump for attachment of patellar ligament
    - Gerdy's tubercle—Protrusion from lateral condyle to which iliotibial tract attaches
    - Shaft—or body, with rough diagonal ridge on posterior proximal end: soleal line
    - Medial malleolus—inferomedial projection at distal end, articulates with talus
- Fibula
  - Slender, nonweightbearing
  - Osteological features
    - Head—proximal end with pointed apex, articulates with tibia
    - Shaft—or body, has three borders (anterior, interosseous, and posterior) and surfaces (anterior, posterior, and lateral) for muscle attachments
    - Lateral malleolus—distal enlargement, articulates with tibia, contributes to ankle joint
- Interosseous membrane uniting tibia and fibula

FASCIAL COMPARTMENTS

- Crural fascia
  - Deep fascia surrounding leg
  - Distal continuation of fascia lata
  - Attaches to anterior and medial borders of tibia
  - Thicker in proximal leg
  - Continues as extensor retinaculum distally
  - Extensions from deep surface—anterior and posterior intermuscular septa—attach to anterior and posterior margins of fibula
- Intermuscular septa and interosseous membrane divide leg into three fascial compartments: anterior, lateral, and posterior.
- Muscles in deep compartment are subdivided into superficial and deep compartments by transverse intermuscular septum.

JOINTS

- Proximal tibiofibular joint
  - Plane-type, synovial joint
  - Nonweightbearing
  - Between head of fibular and lateral condyle of tibia
  - Fibrous capsule reinforced by anterior and posterior ligaments of the head of the fibula
- Distal tibiofibular
  - Fibrous joint (syndesmosis)
  - Medial surface of distal fibula articulates with facet on inferior end of tibia.
  - Reinforced by anterior and posterior tibiofibular ligaments and interosseous ligament (extension of interosseous membrane)

MUSCLES

- Anterior (= extensor) compartment
  - Primarily dorsiflexors of ankle
  - Include
    - Tibialis anterior (also inverts foot and holds up medial longitudinal arch of foot)
    - Extensor hallucis longus (also dorsiflexes hallux and inverts foot)
    - Extensor digitorum longus (also dorsiflexes toes)
    - Peroneus tertius (also everts foot)

Muscles of the Anterior Leg

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Tibialis anterior	Lateral condyle and proximal half of lateral tibia, interosseous membrane	Medial plantar surfaces of medial cuneiform and base of 1st metatarsal	Deep fibular nerve (L4–L5)	Dorsiflexes foot at ankle and inverts foot	Anterior tibial artery
Extensor hallucis longus	Middle part of anterior surface of fibula and interosseous membrane	Dorsal aspect of base of distal phalanx of great toe	Deep fibular nerve (L5–S1)	Extends great toe, dorsiflexes foot at ankle	Anterior tibial artery
Extensor digitorum longus	Lateral condyle of tibia, proximal 3/4 of anterior surface of interosseous membrane and fibula	Middle and distal phalanges of lateral four digits	Deep fibular nerve (L5–S1)	Extends lateral four digits and dorsiflexes foot at ankle	Anterior tibial artery
Fibularis (peroneus) tertius	Distal third of anterior surface of fibula and interosseous membrane	Dorsum of base of 5th metatarsal	Deep fibular nerve (L5–S1)	Dorsiflexes foot at ankle and aids in eversion of foot	Anterior tibial artery

- Lateral (= everter) compartment
  - Primarily everters of the foot
  - Include
    - Peroneus longus
    - Peroneus brevis
  - Both plantarflex ankle, evert foot, and hold up lateral longitudinal arch of foot

Muscles of the Lateral Leg

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Fibularis (peroneus) longus	Head and proximal two thirds of lateral fibula	Plantar base of 1st metatarsal and medial cuneiform	Superficial fibular nerve (L5–S2)	Everts foot, weakly plantarflexes foot at ankle	Anterior tibial and fibular arteries
Fibularis (peroneus) brevis	Distal two thirds of lateral surface of fibula	Dorsal surface of tuberosity on base of 5th metatarsal	Superficial fibular nerve (L5–S2)	Everts foot and weakly plantarflexes foot at ankle	Anterior tibial and fibular arteries

- Posterior compartment
  - Comprised of superficial and deep groups
  - Separated by transverse intermuscular septum
  - Superficial group = plantar flexors of the foot
    - Gastrocnemius
    - Soleus
    - Plantaris
    - Gastrocnemius and plantaris cross knee joint and thus also flex knee
    - All three contribute to calcaneal tendon
  - Deep group = plantar flexors of foot
    - Tibialis posterior (also inverts foot and supports medial longitudinal arch of foot)
    - Flexor hallucis longus (also plantarflexes interphalangeal joint of hallux and supports medial longitudinal arch of foot)
    - Flexor digitorum longus (also plantarflexes DIP joints of lateral four toes and supports medial and lateral longitudinal arches of foot)
- Popliteus
  - Forms inferior floor of popliteal fossa
  - Tendon lies between fibrous capsule and synovial membrane of knee joint
  - Flexes knee
  - Rotates femur five degrees laterally on tibial plateau to unlock knee so flexion can occur

Muscles of the Posterior Leg

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Innervation	Main Actions	Blood Supply
Superficial Muscles					
Gastrocnemius	*Lateral head*: lateral aspect of lateral condyle of femur; *Medial head*: popliteal surface above medial condyle of femur	Posterior aspect of calcaneus via the calcaneal tendon	Tibial nerve (S1–S2)	Plantarflexes foot at ankle joint, assists in flexion of knee joint, raises heel during walking	Popliteal and posterior tibial arteries
Soleus	Posterior aspect of head of fibula, proximal 1/4 of posterior surface of fibula, soleal line of tibia	Posterior aspect of calcaneus via calcaneal tendon	Tibial nerve (S1–S2)	Plantarflexes foot at ankle, stabilizes leg over foot	Popliteal, posterior tibial, and fibular arteries
Plantaris	Inferior end of lateral supracondylar line of femur and oblique popliteal ligament	Posterior aspect of calcaneus via calcaneal tendon	Tibial nerve (L5–S1)	Weakly assists gastrocnemius	Popliteal artery
Deep Muscles					
Popliteus	Lateral aspect of lateral condyle of femur, lateral meniscus	Posterior tibia superior to soleal line	Tibial nerve (L4–S1)	Weakly flexes knee and unlocks it by rotating femur on fixed tibia	Inferior medial and lateral genicular arteries
Flexor hallucis longus	Distal 2/3 of posterior fibula, inferior part of interosseous membrane	Base of distal phalanx of great toe (hallux)	Tibial nerve (L5–S2)	Flexes all joints of great toe, weakly plantarflexes foot at ankle	Fibular artery
Flexor digitorum longus	Medial part of posterior tibia inferior to soleal line	Plantar bases of distal phalanges of lateral four digits	Tibial nerve (L5–S1)	Flexes lateral four digits and plantarflexes foot at ankle; supports longitudinal arches of foot	Posterior tibial artery
Tibialis posterior	Posterior tibia below soleal line, interosseous membrane, proximal half of posterior fibula	Tuberosity of navicular bone, all cuneiforms, cuboid and bases of 2nd through 4th metatarsals	Tibial nerve (L4–L5)	Plantarflexes foot at ankle and inverts foot	Fibular artery

CLINICAL POINTS

COMPARTMENT SYNDROME

- Abnormally high pressure within one of the leg's restricted compartments
- Caused by hemorrhage, edema, or inflammation of the muscles of the leg, often secondary to trauma or deep vein thrombosis
- Increased compartmental pressure causes ischemia and nerve damage.
- May lead to permanent injury of distal structures supplied by effected arteries and veins
- Management is surgical: fasciotomy and debridement of any necrotic tissue.

SHIN SPLINTS (TIBIALIS ANTERIOR STRAIN)

- Edema and pain over distal two thirds of the tibia
- Caused by repetitive microtrauma to the tibialis anterior muscle
- Common in athletic overexertion
- Often seen in persons who do not exercise, after they try a long-distance walk
- A mild form of anterior compartment syndrome
- Chronic condition can cause periostitis and bone remodeling or lead to stress fractures.

RUPTURED ACHILLES TENDON

- Tendonitis of the calcaneal tendon
- A common running injury

- Rupture of the tendon usually occurs in untrained middle-aged individuals with a history of tendonitis.
- Presents as sudden calf pain with an audible snap and subsequent inability to plantarflex the foot.
- Gap is palpable in complete rupture.

MEMORY AIDS

Deep posterior leg muscles (medial to lateral): **D**own **T**he **H**atch
Flexor **D**igitorum longus
Tibialis posterior
Flexor **H**allucis longus

(Structures behind medial malleolus—*see Section 7.5, Ankle and Foot*)

Symptoms of varicose veins: **AEIOU**
Aching
Eczema
Itching
Oedema
Ulceration/**U**gly (varicosities)

7.5 ANKLE AND FOOT

Study Aims

At the end of your study, you should be able to:

- Understand the structure of the ankle mortise and its supporting ligaments and appreciate its vulnerability to injury
- Know the bones of the foot and their organization
- Understand the functional importance of the ligaments and fascia of the foot
- Describe the arches of the foot
- Understand the arrangement of the intrinsic muscles of the foot
- Know the descriptive layers of the plantar surface of the foot

GUIDE

ANKLE JOINT (TALOCRURAL JOINT)

- Uniaxial, synovial, hinge-type joint
- Articulation between tibia (medial malleolus), fibula (lateral malleolus), and talus
  - Distal ends of tibia and fibula form a mortise
  - Trochlea of talus fits into mortise
  - Malleoli grip talus
- Movements
  - Dorsiflexion
    - Produced by muscles of anterior compartment of leg
    - Limited by triceps surae
    - More stable when dorsiflexed
  - Plantarflexion—produced by muscles of posterior compartment of leg
  - Some rotation, abduction, and adduction of joint possible in plantar flexion
- Capsule
  - Thin
  - Supported by strong collateral ligament
  - Attached to tibia and malleoli superiorly and talus inferiorly
- Ligaments
  - Lateral consists of three parts
    - Anterior talofibular—from lateral malleolus to neck of talus
    - Posterior talofibular—from malleolar fossa to lateral tubercle of talus
    - Calcaneofibular—from tip of lateral malleolus to lateral calcaneus
  - Medial or deltoid
    - Strong ligament
    - Originates on medial malleolus
    - Fibers can be identified as
      - Anterior and posterior tibiotalar
      - Tibionavicular
      - Tibiocalcaneal
- Blood supply: malleolar branches of fibular and anterior and posterior tibial arteries
- Nerve supply: Tibial nerve and deep fibular nerve (branch of common fibular)

FOOT

Bones

- 26 in number
- Tarsal bones (7)
  - Talus
    - Head, neck, body with trochlea, posterior, and lateral processes
    - Articulates with fibula, calcaneus, and navicular
    - No muscular attachments
    - Head rests on lateral projection of calcaneus—sustentaculum tali
    - Wider anteriorly, making ankle more stable in dorsiflexion
  - Calcaneus
    - Largest and strongest bone
    - Posterior prominence—calcaneal tuberosity—with medial, lateral, and anterior tubercles
    - Articulates with talus and cuboid
    - Transmits body weight from talus to ground
    - Lateral projection—sustentaculum tali—supports talar head.
  - Navicular
    - Flattened bone with inferomedial tuberosity
    - Located between talar head and three cuneiform bones
  - Cuboid
    - Inferolateral groove for tendon of peroneus longus
    - Most lateral bone in distal row of tarsals
  - Cuneiform (3)
    - Medial, intermediate and lateral
    - Each articulates with navicular posteriorly and base of related metatarsal anteriorly
    - Lateral articulates with cuboid
- Metatarsals (5)
  - Have base (proximal), body, and head (distal)
  - Bases articulate with cuneiform and cuboid bones

  - Head articulates with proximal phalanges
  - Medial and lateral sesamoid bones on plantar surface of 1st metatarsal in plantar ligament
- Phalanges (14)
  - Great toe (hallux) has two—proximal and distal
  - Other toes have three—proximal, middle, and distal
  - Each consists of proximal base, body, and distal head

Joints

- Important intertarsal joints
  - Where inversion and eversion occur
  - Subtalar
    - Synovial joint with where talus rests on calcaneus
    - Fibrous capsule supported by talocalcaneal ligaments
  - Transverse tarsal, composed of
    - Calcaneocuboid joint
    - Talonavicular joint
- Other joints where slight movement occurs
  - Talocalcaneal
  - Tarsometatarsal
  - Metatarsophalangeal (MTP)
  - Interphalangeal: proximal and distal (PIP and DIP)

Arches

- Tarsal and metatarsal bones arranged in longitudinal and transverse arches
- Bony arches maintained by
  - Interlocking bones
  - Plantar ligaments
  - Plantar aponeurosis
  - Action of plantar muscles
- Functions
  - Shock absorbers for body weight
  - Distribute body weight
  - Make foot adaptable to changes in surface
- Longitudinal arch composed of medial and lateral arches
- Medial longitudinal arch
  - Higher arch than lateral
  - Composed of calcaneus, talus, navicular, three cuneiforms, three medial metatarsals
  - Talar head is keystone.
  - Strengthened by
    - Tibialis anterior tendon and attachments
    - Fibularis longus tendon
- Lateral longitudinal arch
  - Flatter than medial
  - Rests on the ground when standing
  - Composed of calcaneus, cuboid, and lateral two metatarsals
- Transverse arch
  - Formed by cuboid, cuneiforms, bases of metatarsals
  - Has pillars formed by lateral and medial longitudinal arches
  - Maintained by fibularis longus tendon

Ligaments (Major Ligaments Listed)

- All foot bones are united by plantar and dorsal ligaments.
- Plantar calcaneonavicular ligament
  - Also called *spring ligament*
  - From sustentaculum tali to navicular
  - Maintains longitudinal arch of foot
- Long plantar ligament
  - From plantar surface of calcaneus to cuboid
  - Maintains foot arches
- Plantar calcaneocuboid ligament
  - Also called short *plantar ligament*
  - Deep to long plantar ligament
  - From inferior surface of calcaneus to inferior surface of cuboid

Plantar Muscles

- Four layers in sole of foot
- Individual muscles of little importance as fine control of the toes is not required
- A neurovascular plane exists between first and second and third and fourth layers.

Intrinsic Foot Muscles

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Layer of Plantar Foot	Innervation	Main Actions	Blood Supply
Abductor hallucis	Medial tubercle of tuberosity of calcaneus, flexor retinaculum, and plantar aponeurosis	Medial side of base of proximal phalanx of 1st digit	First layer: deep to plantar aponeurosis	Medial plantar nerve (S2–S3)	Abducts and flexes 1st toe	Medial plantar and 1st plantar metatarsal arteries
Flexor digitorum brevis	Medial tubercle of tuberosity of calcaneus, plantar aponeurosis, and intermuscular septum	Both sides of middle phalanges of lateral four digits	First layer: deep to plantar aponeurosis	Medial plantar nerve (S2–S3)	Flexes 2nd through 5th toes	Medial and lateral plantar arteries and plantar arch, plantar metatarsal and plantar digital arteries

Muscle	Proximal Attachment (Origin)	Distal Attachment (Insertion)	Layer of Plantar Foot	Innervation	Main Actions	Blood Supply
Abductor digiti minimi	Medial and lateral tubercles of tuberosity of calcaneus, plantar aponeurosis, and intermuscular septum	Lateral side of base of proximal phalanx of 5th digit	First layer: deep to plantar aponeurosis	Lateral plantar nerve (S2–S3)	Abducts and flexes 5th toe	Medial-lateral plantar artery, plantar metatarsal and plantar digital arteries to 5th digit
Quadratus plantae	Medial and lateral sides of plantar surface of calcaneus	Posterolateral edge of flexor digitorum longus tendon	Second layer	Lateral plantar nerve (S1–S3)	Corrects for oblique pull of flexor digitorum longus tendon, thus assists in flexion of toes	Medial and lateral plantar arteries and deep plantar arterial arch
Lumbricals	*1st:* medial side of tendon to 2nd toe; *2nd through 4th:* adjacent sides of contiguous tendons	Medial side of dorsal digital expansions	Second layer	Medial one: Medial plantar nerve Lateral three: Lateral plantar nerve (S2–S3)	Flex proximal phalanges at MP joint, extend distal phalanges at PIP and DIP joints	Superficial and deep palmar arches
Flexor hallucis brevis	Plantar surfaces of cuboid and lateral cuneiform	Both sides of base of proximal phalanx of 1st digit	Third layer	Medial plantar nerve (S1–S2)	Flexes proximal phalanx of 1st digit	Medial plantar artery, 1st plantar metatarsal artery
Adductor hallucis	*Oblique head:* bases of 2nd through 4th metatarsals; *Transverse head*: ligaments of metatarsophalangeal joints of digits 3–5	Tendons of both heads lateral to side of base of proximal phalanx of 1st digit	Third layer	Deep branch of lateral plantar nerve (S2–S3)	Adducts 1st toe, maintains transverse arch of foot	Medial and lateral plantar arteries and plantar arch, plantar metatarsal arteries
Flexor digiti minimi brevis	Base of 5th metatarsal	Lateral base of proximal phalanx of 5th digit	Third layer	Superficial branch of lateral plantar nerve (S2–S3)	Flexes proximal phalanx of 5th toe	Lateral plantar artery, plantar digital artery to 5th digit, arcuate artery
Plantar interossei (3)	Bases and medial sides of 3rd through 5th metatarsals	Medial sides of bases of proximal phalanges of 3rd through 5th digits	Fourth layer	Lateral plantar nerve (S2–S3)	Adduct digits (2–4) and flex metatarsophalangeal joint and extend phalanges	Lateral plantar artery and plantar arch, plantar metatarsal and plantar digital arteries
Dorsal interossei (4)	Adjacent sides of 1st through 5th metatarsals	*1st*: medial side of proximal phalanx of 2nd digit; *2nd through 4th:* lateral sides of digits 2–4	Fourth layer	Lateral plantar nerve (S2–S3)	Abduct 2nd through 4th toes, flex metatarsophalangeal joints, and extend phalanges	Arcuate artery, dorsal and plantar metatarsal arteries

Dorsal Muscles of Foot

- Form bulge on dorsolateral surface of foot, anterior to lateral malleolus
- Two muscles blend together
- Extensor digitorum brevis
  - Proximal attachment: superior surface, anterolateral calcaneus
  - Splits into four muscles, each with a tendon that blends with that of long extensor
  - One tendon to great toe
  - Other tendons to 2nd to 4th toes
- Extensor hallucis brevis
  - Largest and most medial belly of extensor digitorum brevis
  - Inserts on proximal phalanx of great toe
- Supplied by deep fibular nerve
- Assist extensor digitorum longus in extending toes

Fascia

- Deep fascia on dorsum of foot
  - Thin on dorsum
  - Continuous with inferior extensor retinaculum
  - Over lateral and posterior aspects it is continuous with plantar fascia.
- Deep fascia of plantar surface of foot
  - Central condensation of plantar fascia forms plantar aponeurosis.
  - Arises from calcaneus
  - Divides into five fibrous bands that split to enclose digital tendons
  - Vertical septa from deep surface divide the foot into medial, central, and lateral compartments.
- Functions of plantar fascia
  - Holds foot together
  - Protects sole of foot from injury
  - Supports longitudinal arches

CLINICAL POINTS

ANKLE SPRAIN

- As a result of tears in fibers of ligaments supporting the ankle
- Commonly the result of forced inversion of foot causing strain on weaker lateral ligaments
- Anterior talofibular ligament most likely to tear
- Result in instability of ankle joint
- Calcaneofibular ligament may also be torn

ANKLE FRACTURE

- Severe ankle strain may fracture the medial, or more commonly, the lateral malleolus.
- A Pott's fracture-dislocation occurs when foot is forcefully everted, shearing off the medial malleolus.
- Lateral malleolus is then snapped as the talus moves laterally.
- May also fracture fibula above distal tibiofibular joint and distal end of tibia

PLANTAR FASCIITIS

- Microtrauma to proximal attachment of the plantar aponeurosis to the calcaneus, resulting in inflammation of plantar aponeurosis
- Caused by repetitive strain on the longitudinal plantar arch, such as during extensive running or high impact aerobics
- Pain felt over the proximal plantar surface of the foot
- Especially painful after sitting and first thing in the morning
- Treatment is conservative with rest and analgesia.

MEMORY AIDS

Structures traveling behind medial malleolus (anterior to posterior): **T**om, **D**ick **AN**d **H**arry
Tibialis posterior flexor, **D**igitorum longus flexor, **H**allucis longus, **AN**= Posterior tibial **A**rtery and tibial **N**erve
Interossei muscles: **P**lantar interossei **Ad**duct the digits (**PAD**) **D**orsal interossei **Ab**duct the digits (**DAB**)

Muscles that can potentially be absent in the body: 5 P's:

Palmaris longus	[Upper limb]
Plantaris	[Lower limb]
Peroneus*	[Lower limb]
Pyramidalis	[Anterior abdominal wall]
Psoas minor	[Posterior abdominal wall]

7.6 NEUROVASCULATURE

Study Aims

At the end of your study, you should be able to:

- Describe the arterial supply of the lower limb, distinguishing the arteries supplying each of the compartments of the thigh and leg
- Know the surface markings to locate the femoral artery and palpate the pulses of the popliteal, posterior tibial, and dorsalis pedis arteries
- Describe the venous drainage of the lower limb
- Describe the lymphatic drainage of the lower limb
- Know the nervous innervation to the compartments of the thigh and leg and recognize the course of the major nerves of the lower limb
- Understand the dermatome and myotome maps of the lower limb

GUIDE

VASCULAR SUPPLY: ARTERIES

- Femoral artery
  - Continuation of external iliac artery
  - Main artery of lower limb
  - Palpable inferior to midinguinal point, not *at* midpoint of inguinal ligament
  - Descends in femoral triangle on iliopsoas and pectineus, lateral to femoral vein
  - Enters adductor canal deep to sartorius and exits at adductor hiatus
- Profunda femoris (deep artery of thigh)
  - Main artery to thigh
  - Largest branch of femoral

*Peroneus (fibularis) tertius

  - Arises from lateral aspect of femoral in femoral triangle
  - Supplies anterior and medial (adductor) compartments of the thigh
  - Supplies posterior compartment by perforating arteries
  - Gives off medial and lateral circumflex femoral arteries that supply head of femur and muscles of lateral thigh
- Obturator artery
  - Branch of internal iliac artery (or may arise from the inferior epigastric)
  - Enters thigh through obturator foramen
  - Divides into anterior and posterior branches
  - Supplies adductor compartment of thigh along with profunda femoris
- Popliteal artery
  - Continuation of femoral artery (at adductor hiatus)
  - Palpable in popliteal fossa *(best felt when knee is flexed)*
  - Gives off five genicular branches supplying articular capsule and ligaments of knee joint
    - Medial and lateral superior genicular
    - Middle genicular
    - Medial and lateral inferior genicular
    - Form anastomosis around knee joint
  - Bifurcates into anterior and posterior tibial arteries
- Anterior tibial artery
  - Smaller of two terminal branches of popliteal
  - Passes through gap in interosseous membrane
  - Supplies muscles of anterior compartment of leg
  - Descends on interosseous membrane and becomes dorsalis pedis artery
- Posterior tibial artery
  - Larger of two terminal branches of popliteal
  - Supplies muscles of posterior compartment
  - Gives off fibular artery
  - Descends deep to soleus
  - Provides main blood supply to foot, after passing inferior to medial malleolus
  - Palpable behind medial malleolus
  - Gives off nutrient artery to tibia
- Circumflex fibular artery
  - Arises from origin of anterior or posterior tibial
  - Passes over neck of fibula to anastomosis around knee
- Fibular artery
  - Largest branch of posterior tibial
  - Supplies muscles of lateral compartment of the leg
  - Begins below tendinous arch of soleus
  - Gives off nutrient artery to fibula
  - Pierces interosseous membrane to reach dorsum of foot
- Dorsalis pedis
  - Continuation of anterior tibial artery
  - Palpable between 1st and 2nd metatarsal heads
  - Divides into plantar and arcuate arteries
  - Supplies muscles on dorsum of foot
  - Pierces 1st dorsal interosseous muscle as deep plantar artery of foot (plantar arterial arch)
- Medial plantar artery
  - Smaller of two terminal branches of posterior tibial artery
  - Supplies muscles of great toe, skin on medial side of sole
  - Gives off plantar digital arteries
- Lateral plantar artery
  - Larger than medial
  - Accompanies lateral plantar nerve
  - Arches medially across foot, beginning at base of 5th metatarsal as deep plantar arch
  - Gives off four plantar metatarsal arteries
  - Joins branches of medial plantar to form plantar digital arteries to toes

VASCULAR SUPPLY: VEINS

- Lower limb has superficial and deep venous systems with perforating veins communicating between them
- Veins have valves
- Veins of foot
  - Superficial
    - Metatarsal veins merge to form dorsal venous arch
    - Communicates with plantar arch
    - Both drain medially to great saphenous vein and laterally to small saphenous vein
  - Deep
    - Begin as dorsal digital and plantar digital veins
    - Merge to deep veins accompanying arteries in leg and thigh
- Superficial veins of leg and thigh
  - Great saphenous vein
    - Courses along medial side of dorsum of foot
    - Passes in front of medial malleolus *(location for venous cut down for emergency IV access here)*
    - Anastomoses freely with small saphenous vein
    - Ascends medial side of leg, then posterior to knee
    - Ascends along medial thigh to saphenous hiatus in fascia lata
    - Traverses hiatus to empty into femoral vein
    - Many valves
  - Small saphenous vein
    - Runs behind the lateral malleolus
    - Ascends along lateral border of calcaneal tendon
    - Pierces deep fascia
    - Ascends between heads of gastrocnemius
    - Empties into popliteal vein
    - Accompanied by sural nerve
- Deep veins of leg and thigh
  - Accompany all major arteries (venae comitantes)
  - Usually paired
  - Variable and anastomose freely
  - Unite to form popliteal vein and ascend as femoral vein
- Perforating veins
  - Penetrate deep fascia
  - Connect superficial and deep veins
  - Have valves

LYMPHATICS

- Superficial lymphatics follow superficial veins
  - Lymphatics following great saphenous drain into superficial inguinal nodes
  - Lymphatics following small saphenous vein drain into popliteal nodes

- Deep lymphatics
  - Follow vasculature in muscle compartments
  - Drain to deep inguinal nodes
- Popliteal nodes drain into deep inguinal nodes

NERVES

- Cutaneous nerves
  - Subcostal nerve (T12) to skin anterior to greater trochanter
  - Iliohypogastric nerve (L1) to superior lateral buttock
  - Ilio-inguinal (L1) to proximal and medial thigh
  - Genitofemoral nerve (L2–L3) to immediately inferior to middle inguinal ligament
  - Lateral femoral cutaneous ((L2–L3) to lateral and anterior thigh
  - Femoral nerve (L2–L4)
    - Via anterior femoral cutaneous branches to anterior and medial thigh
    - Via saphenous nerve to medial side of leg and foot
  - Obturator nerve—branch to anterior, medial, and posterior proximal thigh
  - Posterior femoral cutaneous nerve—to posterior thigh and popliteal region
  - Sciatic nerve
    - Supplies foot and most of leg
    - Via sural, common, superficial, and deep fibular nerves
  - Cluneal nerves (superior middle and inferior)—buttock
- Nerves to muscles of lower limb from lumbosacral plexus
- Nerves in the gluteal region
  - Superior gluteal nerve (L4–S1)
    - Emerges superior to piriformis
    - Supplies gluteus medius, gluteus minimus, and tensor fasciae latae
  - Inferior gluteal nerve (L5–S2)
    - Inferior to piriformis
    - Supplies gluteus maximus
  - Nerve to quadratus femoris (L4–S1): also supplies inferior gemellus
  - Pudendal nerve (S2–S4): supplies the perineum *(not structures in gluteal region)*
  - Nerve to obturator internus (L5–S2)
- Nerves to anterior and lateral thigh
  - Femoral nerve (L2–L4)
    - Enters thigh lateral and deep to femoral artery
    - Supplies the anterior compartment of the thigh
  - Obturator nerve (L2–L4)
    - Enters thigh through obturator foramen and divides into anterior and posterior branches
    - Supplies medial (adductor) compartment of thigh
- Nerves of posterior thigh
  - Sciatic nerve (L5–S2)
    - Enters gluteal region from pelvis through greater sciatic foramen
    - Emerges inferior to piriformis muscle
    - Supplies no structures in gluteal region
    - Supplies posterior thigh muscles
    - Bifurcates in lower third of thigh into tibial and common fibular nerves
    - Via tibial and common fibular nerves, supplies all leg and foot muscles
- Nerves of leg
  - Tibial nerve
  - Supplies the posterior compartment of leg
  - Ends by dividing into medial and lateral planter nerves
  - Common fibular nerve
  - Wraps around fibular head
  - Divides into deep and superficial peroneal nerves
    - Deep fibular nerve supplies anterior compartment of leg
    - Superficial fibular nerve supplies lateral compartment of leg
- Nerves of foot
  - Medial plantar to 3½ muscles of plantar foot
  - Lateral plantar to remaining muscle of plantar foot

DERMATOMES

Myotomes

- A group of muscles supplied by fibers from a single spinal nerve or a discrete group of spinal nerves is called a myotome.

Myotomes of the Lower Limb

		L2	L3	L4	L5	S1	S2
Hip	Flexion	X	X				
	Extension			X	X		
Knee	Extension		X	X			
	Flexion				X	X	
Ankle	Dorsiflexion			X	X		
	Plantarflexion					X	X
Foot	Inversion			X	X		
	Eversion				X	X	
	Intrinsic						X

CLINICAL POINTS

CHRONIC ARTERIAL OCCLUSIVE DISEASE

- Caused by atherosclerosis
- In the lower limb, most commonly affects the femoral artery as it passes through adductor canal
- Symptoms of intermittent claudication (pain in a muscle group because of poor blood supply) brought on by exertion in the early phase; may progress to pain at rest
- Ischemic ulcers can also develop.
- Patients with advanced disease require vascular surgical intervention with bypass or endarterectomy.

FOOTDROP

- Injury to the common fibular nerve can result in loss of eversion and dorsiflexion of the foot.
- Foot drops and toes drag on the ground when walking unless high-stepping gait is employed.
- Variable amount of sensation also lost on the anterolateral aspect of the leg and dorsum of foot.
- Nerve is vulnerable owing to superficial course as it wraps around fibular neck.
- Nerve may be severed during fracture of fibula or dislocation of knee joint.

MERALGIA PARESTHETICA (GUNSLINGER'S NEURALGIA)

- Compression of the lateral cutaneous nerve of the thigh against the anterior superior iliac spine
- Causes a stinging or burning sensation in the anterolateral thigh
- Was caused by low-riding gun belt in the Old West

MEMORY AIDS

Nerves of the leg and their functions

FED: Fibular nerve **E**verts and **D**orsiflexes the foot
TIP: Tibial nerve **I**nverts and **P**lantarflexes the foot

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Head & Neck

UNC 1. Posterior Neck and Suboccipital Region: Step 5. Suboccipital triangle

UNC 2. Posterior Neck and Suboccipital Region: Step 6. Exposure of the posterior arch of C1 and related structures

UNC 3. Posterior Neck and Suboccipital Region: Step 7. Vertebral artery and suboccipital nerve

UNC 4. Anterior Neck: Step 6. Infrahyoid and digastric muscles; submandibular gland

UNC 5. Anterior Neck: Step 7. Subdivisions of the anterior triangle

UNC 6. Brain: Step 1. Cerebral hemispheres, lobes, fissures, gyri and sulci

UNC 7. Brain: Step 2. Diencephalon: mammillary bodies, pituitary gland, tuber cinereum, optic nerves, and pineal gland

UNC 8. Brain: Step 3. Mesencephalon: cerebral peduncles, interpeduncular fossa, oculomotor nerve, trochlear nerve, and corpora quadrigemini

UNC 9. Brain: Step 4. Metencephalon: pons and cerebellum and associated cranial nerves

UNC 10. Brain: Step 5. Medulla oblongata: olive, pyraminds, apertures, and choroid plexus of the fourth ventricle

UNC 11. Brain: Step 6. Cerebral arterial circle (of Willis)

UNC 12. Brain: Step 7. Middle, anterior and posterior cerebral arteries

UNC 13. Brain: Step 8. Midsagittal section of the brain

UNC 14. Brain: Step 9. CN III, V, and VI in the floor of the cranial cavity; trigeminal cave and ganglion; mandibular division of CN V

UNC 15. Cranial Cavity and Dural Venous Sinuses: Step 10. Reflection of the tentorium cerebelli and removal of the brain

UNC 16. Cranial Cavity and Dural Venous Sinuses: Step 11. Dural venous sinuses

UNC 17. Eye and Orbit I: Step 2. Frontal nerve

UNC 18. Eye and Orbit I: Step 3. Superior oblique muscle; trochlear and lacrimal nerves

UNC 19. Osteology of the Head and Neck: Step 7. Cranial sutures

UNC 20. Osteology of the Head and Neck: Step 19. Foramina in the base of the skull

Back & Spinal Cord

UNC 21. Vertebral Column and Its Contents: Step 2. Epidural space and dura mater

UNC 22. Vertebral Column and Its Contents: Step 3. Spinal cord, conus medullaris, internal filum terminale, arachnoid membrane

Thorax

UNC 23. Coronary Circulation and Internal Structure of the Heart: Step 4. Internal anatomy of the right atrium

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UNC 24. Coronary Circulation and Internal Structure of the Heart: Step 5. Internal anatomy of the right ventricle

UNC 25. Posterior Mediastinum, Azygos System: Step 1. Vagus and recurrent laryngeal nerves

UNC 26. Posterior Mediastinum, Azygos System: Step 2. Relationship of the esophagus to the tracheal bifurcation and thoracic vertebrae

Abdomen

UNC 27. Anterior Abdominal Wall and Abdominal Viscera in situ: Step 11. Ligaments of the liver

UNC 28. Anterior Abdominal Wall and Abdominal Viscera in situ: Step 12. Abdominal viscera in situ

UNC 29. Stomach, Duodenum, Portal System, and Inferior Mesenteric Artery: Step 8. Internal anatomy of the duodenum

UNC 30. Stomach, Duodenum, Portal System, and Inferior Mesenteric Artery: Step 9. Duct system within the pancreas

Pelvis & Perineum

UNC 31. Female Pelvic Viscera: Step 1. Pelvic viscera in situ

UNC 32. Female Pelvic Viscera: Step 5. Pelvic ligaments and uterine tube

UNC 33. Somatic Nerves of the Greater and Lesser Pelvis; Pelvic Diaphragm: Step 6. Lumbosacral trunk and sacral plexus

UNC 34. Somatic Nerves of the Greater and Lesser Pelvis; Pelvic Diaphragm: Step 7. Obturator internus fascia and the arcus tendineus

Upper Limb

UNC 35. Posterior Shoulder: Step 2. Rhomboid major, rhomboid minor, and levator scapulae muscles; accessory nerve

UNC 36. Posterior Shoulder: Step 3. Innervation of the rhomboid and latissimus dorsi muscles; the dorsal scapular and thoracodorsal nerves

UNC 37. Flexor Surface of the Forearm: Step 4. Pronator teres and muscular branches of the median nerve

UNC 38. Flexor Surface of the Forearm: Step 5. Sectioning of first layer of flexor muscles

Lower Limb

UNC 39. Medial and Anterior Thigh: Step 4. Sartorius muscle; medial and lateral inter muscular septa

UNC 40. Medial and Anterior Thigh: Step 5. Quadriceps femoris muscle

UNC 41. Popliteal Fossa, Knee Joint, and Posterior Compartment of the Leg: Step 5. Triceps surae and its innervation

UNC 42. Popliteal Fossa, Knee Joint, and Posterior Compartment of the Leg: Step 6. Contents of the deep posterior compartment of the leg

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